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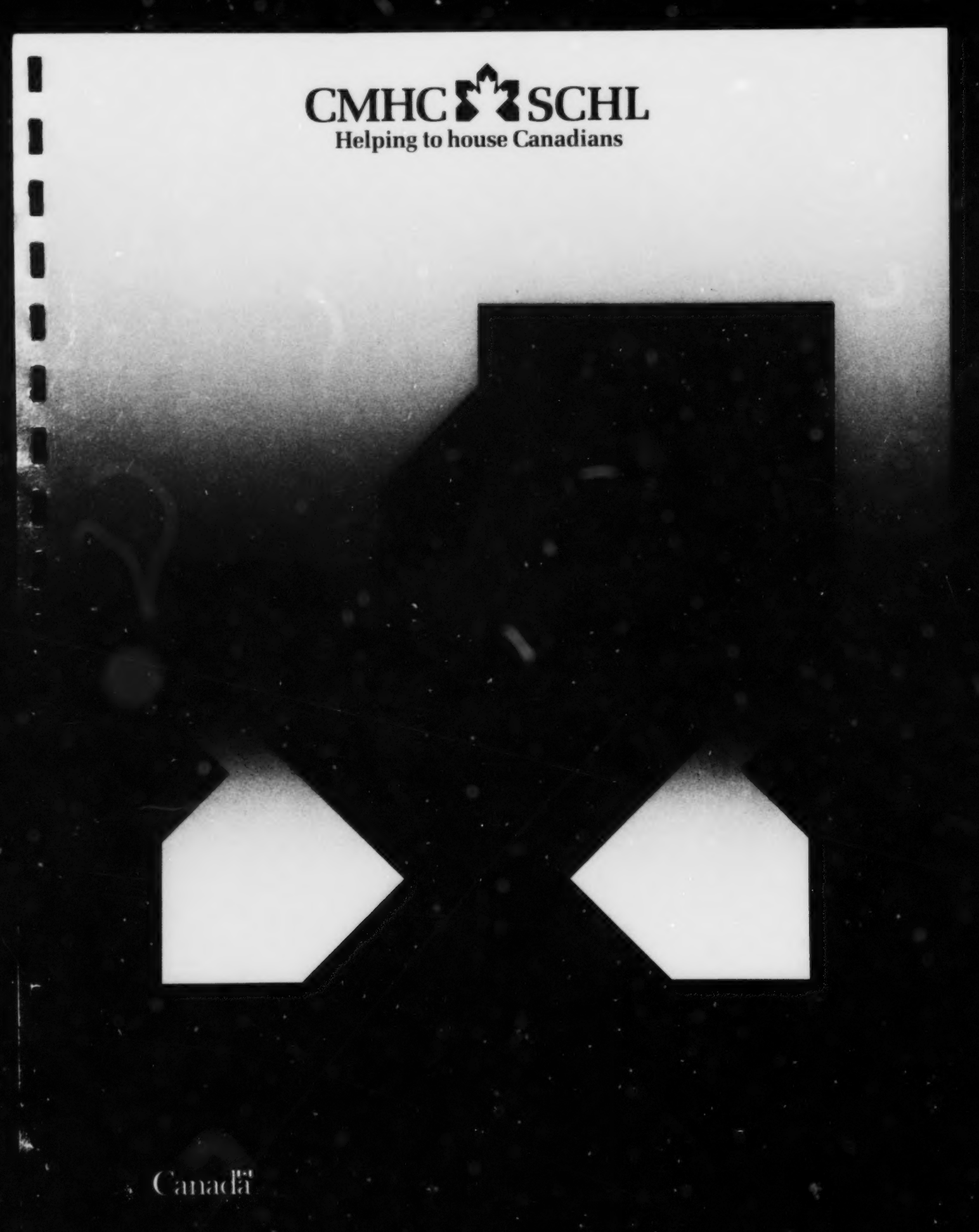

Canada

RESIDENTIAL WATER CONSERVATION:

A REVIEW OF PRODUCTS, PROCESSES AND PRACTICES

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Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act. This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

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Abstract

This publication provides an in-depth review of residential water-conserving products, processes and programs. The focus is on Canada, however, relevant U.S. products and experiences are also discussed. The publication is divided into four main sections. Section 1 introduces the publication and provides the context for understanding the need for water conservation. Section 2 documents the range of conservation initiatives open to the various levels of government and their agencies responsible for water management. Section 3 provides an introduction to and description of the technology available for reducing residential water use, looking at both interior and exterior water use. Section 4 looks at codes and standards issues, examining barriers to the widespread introduction of water-efficient products and equipment, and mechanisms for overcoming these barriers.

The publication will be of value to individuals attempting to understand water issues on a broad scale, as well as to those looking for specific solutions to water quantity problems in any one location or jurisdiction.

Executive Summary

Introduction

This report provides a review and critique of the current outlook for residential water conservation in Canada. It addresses a wide range of residential water conservation technologies and practices currently available in the marketplace. It reviews not only products and equipment, but also government programs and mandates, and the challenges posed by jurisdictional overlap involving water resource planning and conservation.

Although Canadians rank second only to U.S. consumers in per capita consumption of water, there are significant opportunities identified and discussed in the report which, when implemented, will lead to substantial reductions in residential water consumption. Household reductions in water consumption in the order of 10 to 15 percent are possible with current, off-the-shelf technology. More advanced technology is also available to reduce average household consumption of water by up to 50 percent, with no detectable changes in lifestyle.

Recognizing that the municipality is the principal water retailer for about 75% of the Canadian population, considerable space is devoted in the report to the municipal jurisdiction as a source of consumer information and education about water and sewer infrastructure. This report indicates that some of the more problematic barriers to the introduction of more water-efficient technology into the residential sector are as much attitudinal — and bureaucratic — as they are technological.

While it may be difficult to argue for water conservation from a *sustainability of the resource* perspective in most Canadian municipalities — with notable exceptions — there is a growing recognition of the need for full cost accounting of all municipal services. In the face of rising costs and diminishing transfer payments from senior levels of government, water conservation — i.e., water demand management — is becoming a priority for an increasing number of Canadian municipalities, simply in response to growing concerns about the *sustainability of infrastructure*.

Rural water and wastewater issues are also addressed, particularly from the standpoint of the impacts of water use and sewage disposal on the operating efficiency and lifespan of disposal systems, and impacts on ground water and aquifers.

Objectives

The primary objectives of this discussion document are to:

- document residential water conservation practices, products and approaches used successfully elsewhere;
- identify the advantages to and implications for Canada of using similar products and approaches;
- investigate the codes and standards issues as they affect the introduction and widespread use of water-efficient products and equipment and provide recommendations for effectively addressing any identified barriers associated with codes and standards;
- identify the scope of possible residential water-efficiency design criteria; and,
- provide a recommended marketing strategy to ensure that residential water conservation initiatives effectively reach the proper target audience.

Methodology

The report is organized around several different, but related, water conservation contexts or fields, outlined below:

- An introduction provides a context which will permit individuals to understand the need for water conservation and water demand management.

- The range of initiatives open to, and undertaken by, the various levels of government and their agencies responsible for water management is discussed. The context for this jurisdictional discussion is provided by a brief review of the related constitutional mandates of the three levels of government in Canada.

- A description is provided of several examples of effective water conservation practices demonstrated in the United States, focussing in particular on three case studies from Boston, Seattle, and San Jose.

- A detailed description is presented of the technology available for reducing residential water use, looking at both interior and exterior water use.

- Codes and standards issues are examined, revealing that, although there are currently barriers to the widespread introduction of water-efficient products and equipment into the residential sector in Canada, there are mechanisms to reverse this situation, based on several U.S. examples which are highlighted.

- An analysis and discussion of several key issues which are identified in the report, including infrastructure planning concerns, codes and standards implications, and consumer marketing issues, are included in the appendices. An annotated bibliography, plus a series of charts and graphs referenced in the main body of the report appears in the appendices.

Findings

Establishing the Need for Water Conservation

Although Canada is a water-rich nation, water conservation is becoming an increasingly important public policy issue. All levels of government are beginning to recognize that, while the sustainability of the resource is not threatened, the ability of governments — provincial and municipal — to sustain the water and sewer infrastructure is being questioned.

Where previously, municipalities tended to rely on increases in *supply* to meet rising demand for water and sewer services, there is now growing recognition of the impact that *demand management* can have in improving the productivity of municipal water and sewer infrastructure, while still providing an acceptable level of service to all customer classes.

The price mechanism will increasingly play a role in demand management. Historically, Canada has had some of the lowest water prices in the world, which has lead to the resource being undervalued and overused. It is generally agreed that a realistic pricing scheme incorporating the notion of full cost accounting, will curtail water use and reduce demands on treatment facilities.

Jurisdictional Issues

The federal and provincial levels of government in Canada set the overall framework for water policy. They play a supportive and encouraging role, either by developing consumer awareness about water conservation, or by establishing statutory and related enabling legislation to clear the way for the adoption of more water efficient technology and practices.

However, it is at the municipal level where most of the opportunities for conservation and demand management are implemented. Practical issues associated with the design, delivery and evaluation of municipal water conservation programs are being tested in numerous municipal contexts across the country.

Although the level of government closest to most water consumers, municipalities are, paradoxically, both constrained and empowered when it comes to implementing water conservation programs. They are free to develop or deliver consumer education programs about water conservation. However, they cannot make laws and, therefore, do not have the right to legislate water conservation measures beyond reactive lawn watering bans. And, where they do have authority, their actions cannot supersede provincial regulations in the same area.

Evidence from several U.S. municipal case studies points the way to promising directions for the future. Participation rates for household water conservation retrofit kits vary, depending on the method of distribution. Participation rates are highest for direct installation methods, and lowest for the depot pickup method.

The level of local public awareness and enthusiasm about environmental issues appears to be a factor in boosting public interest in water conservation programs. This suggests the importance of putting an environmental "spin" on the water conservation issue to increase participation rates. This observation is reinforced by the "blue box" recycling programs which incorporated a similar environmental message, and which now have household participation rates as high as 98 percent in some municipalities.

Water Efficient Technology

There is a wide range of water efficient technology currently available for application both inside and outside the home. The most significant area in the home for reducing water consumption is the bathroom, where about 75 percent of all household water is consumed. Simply replacing a conventional 20 litre per flush toilet with a 6 litre ultra-low-volume flush toilet will reduce water consumption associated with toilet flushing by 70 percent, and total household water consumption by nearly 30 percent.

It has been estimated that using only low-cost approaches, and less than state of the art fixtures, water use in a new residence could be cut from 30 to 50 per cent with no attendant changes in lifestyle. Those same approaches and fixtures in a retrofit situation, could reduce water use from 19 to 44 per cent.

A 1991 Ontario study estimated that installing low-flow aerators in the kitchens and bathrooms in a 719 unit apartment highrise, would reduce water use by 33 per cent. That in-turn would yield an annual savings in water, wastewater, and natural gas charges equal to the costs of the purchase and installation of the low-flow aerators, resulting in a payback of one year.

Conclusions

There appears to have emerged a genuine need for basic research into the economic impacts associated with water conservation, (i.e., development cost, building costs, utility and infrastructure life, etc.) A fuller understanding of this relationship will permit a more appropriate approach to the funding of research, development, demonstration and implementation.

Harmonization of Canadian-U.S. standards is needed to cost effectively deliver water conserving technologies to the marketplace. The interests of established manufacturers and the limited resources within CSA for standards research and development make it difficult for this harmonization to be achieved.

The necessary Canadian Plumbing Code changes to reflect low consumption fixture hydraulic loads and venting requirements are believed to be minimal, but necessary, to allow designers to gain the full economic benefit associated with low consumption fixtures. This may also provide an opportunity to rationalize many aspects of the plumbing code

which represent inherited empirical prescriptive requirements which may be out of date, rather than technically supported performance requirements.

Communications initiatives aimed at educating municipal engineering departments who have expressed concerns relating to low-consumption fixtures will be required. These initiatives should reduce barriers to water conservation measures, as well as assist in explaining the far reaching benefits associated with water conservation.

Consumer awareness and education is needed to drive water efficient technology in the marketplace.

Preface

It has been stated many times that Canada is a water-rich nation. The country contains an astounding 20 per cent of the world's fresh water resources. From the air, it is a country that often looks more like islands surrounded by lakes, than lakes surrounded by terrain. The measurable contribution of water to the Canadian economy has been estimated to be between 7.5 billion and 23 billion dollars per year.[1] On the surface, it seems hard to believe that this endless supply of fresh water could in any way be threatened.

And yet it is a resource under pressure. To begin with, only 9 per cent of our water reserves are available for use; the rest has been termed "fossil water", an unusable legacy left by the last age of glaciers.[2] In addition, ninety per cent of Canadians live within one hundred and fifty miles of the southern border, while sixty per cent of river discharge runs to the north. That would still leave more than enough water to service a relatively small population, were it not for the fact that these supplies are coming under increasing development pressures.

These facts, however, have done little to quench an our thirst for fresh water. Demand for potable water has increased more than six-fold in the past ninety years — 75 per cent of this increase occuring over the past 25 years. In a number of regions the rate of water withdrawal has outstripped the groundwater aquifer's natural discharge rate, a situation that threatens to become commonplace in the coming decade.

Concomitant with an increase in demand, is an increase in the amount of wastewater that needs to be treated and purified. Costs of providing sewage treatment and water purification have risen significantly, particularly the costs associated with the expansion of existing physical plant capacity, and the construction of new treatment facilities. What is most troubling is that this is happening at a time when transfer payments from the federal government to the provinces, and from the provinces to municipalities, are entering a period of constraint.

Any measure that will reduce the demand for potable water and the production of wastewater has very tangible benefits for provincial and municipal agencies charged with the responsibility of providing water and sewer infrastructure. Studies in the United States have shown that reductions in wastewater production in the order of 10 per cent can significantly extend the life and operating efficiency of existing facilities, while postponing the need for costly infrastructure expansion.[3]

One of the best ways to reduce the demand for potable water and the production of wastewater is by improving the productivity or efficiency of water use, by changing equipment, using it more efficiently, and by reducing the amounts of water currently wasted.

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1.0
Introduction

This study has been commissioned by the Canada Mortgage and Housing Corporation to identify and examine the range of residential water conservation approaches currently available and practiced in Canada and the United States. The report does not limit itself simply to describing water efficient *technology*. While it does review the wide range of products, equipment and devices designed to save water or reduce water consumption in the residential sector, it deals also with *techniques and approaches* which various jurisdictions can take to foster or promote water conservation.

The primary objectives of this report document are to:

- document residential water conservation practices, products and approaches used successfully elsewhere;
- identify the advantages to and implications for Canada of using similar products and approaches;
- investigate the codes and standards issues as they affect the introduction and widespread use of water-efficient products and equipment and provide recommendations for effectively addressing any identified barriers associated with codes and standards;
- identify the scope of possible residential water-efficiency design criteria; and,
- provide a recommended marketing strategy to ensure that residential water conservation initiatives effectively reach the proper target audience.

To provide the context for jurisdictional discussions, the authors have provided a brief review of the roles, mandates and restrictions of the three levels of government in Canada, as they relate to the introduction of water conservation measures into the marketplace. Although the federal and provincial levels of government have a leadership role to play in the broader policy issues affecting water resources, it is at the municipal level that much of the opportunities to promote water conservation must be explored.

This report has taken into consideration, if only in a very preliminary way, the jurisdictional issues affecting how, when, where, and why water conservation could become an accepted part of everyday life in Canada.

2.0
Jurisdictional Issues

Opportunities to develop and implement water conservation initiatives exist at all three levels of government: federal, provincial, and municipal. Similarly, limitations to the promotion of water conservation exist at all three levels; not the least of which is the division of authority between the governments, the division of authority between various agencies at each level, and the lack of a comprehensive conservation strategy that assigns each player a specific role.

This section provides an overview of the limitations and opportunities that both inhibit, and support government action. Specifically, Subsection 2.1 deals with the federal government and examines the constitutional basis that provides the federal government authority for action as well as the governments proposed water conservation initiatives as outlined in the Federal Water Policy.

Subsection 2.2 deals with provincial governments, beginning with an examination of the legal basis for provincial action in regard to water conservation. Seven mechanisms open to provincial governments for the promotion of conservation initiatives are identified and discussed.

Subsection 2.3 addresses limitations and opportunities at the municipal level. Given that municipal governments are, potentially, in the most powerful position to affect water consumption, this is the largest and most detailed of the three subsection.

Finally, Subsection 2.4 moves from the abstract and theoretical to the practical, with a discussion of the U.S. experience in this field, both in terms of residential water conservation retrofits, and from the standpoint of the development of water efficient codes and standards.

2.1
Federal Water Conservation Initiatives

The Constitution Act divides the responsibility for management of water resources between federal and provincial governments. While the Act does not make direct reference to water, the provinces, because of their jurisdiction over management of public lands, property, and matters of a local nature, exercise proprietary rights over the resources (e.g. water) within their borders. The federal government has proprietary rights over resources in areas of solely federal jurisdiction, as well as legislative jurisdiction over inland fisheries and commercial navigation.[1]

Where domestic water consumption is concerned, provincial governments have more power to influence supply and demand. However, the federal government is not without the resources to affect water quality and quantity issues at a provincial, local, and even individual level.

This section briefly examines the water conservation mechanisms open to the federal government. In particular, it looks at the strategies identified by the government itself in the Federal Water Policy.

2.1.1
Federal Water Policy

As noted above, the federal government does not have direct legislative control over water issues at a residential level. Nor has water conservation been a large concern of the federal government over the years. Where it has dealt with water issues, it has traditionally been in a remedial fashion, focusing on mitigating effects as opposed to rooting out causes. With the publication of the Federal Water Policy (Ottawa, 1987), however, the federal government has recognized the need for water conservation, and outlined a proactive role for the government to play.

This policy has two goals:

- *protecting and enhancing the quality of the water resource; and*
- *promoting the wise and efficient management and use of water.*

To reach the goals, the Federal Water Policy outlines five strategies, including:

1. Water Pricing: a commitment to the concept of "a fair value for water", the notion of user pay through "realistic water pricing" (as identified in the federal government's Green Plan), and the recognition of the need to move to full cost accounting for water (and sewer) services;
2. Scientific Leadership: using the government's position as a national leader to promote the scientific and socio-economic research, and technological development of the tools necessary for effective water management;

3. Integrated Planning: a commitment to long term planning for the development and management of water resources;
4. Legislation: a strengthening of the application of existing federal legislation to protect the quality and quantity of water; and
5. Public Awareness: encourage public participation and develop a national water conservation awareness program.

While all five strategies hold some potential for the development of conservation oriented policies and practices, only strategies one and five bear directly and immediately on water conservation at a residential level. The others, in large, deal with issues more on a provincial and international level, though ultimately, they will have a trickle-down effect on how water is used at a personal level.

2.1.2 Water Pricing

The Policy notes that Canada's water prices are among the lowest in the world. As a consequence the resource has been undervalued and overused. As the Policy states, "a realistic pricing scheme would make users conscious of the real value of the resource," and reduce demands on overburdened treatment facilities.[2]

The Policy goes on to state that the federal government is committed to the concept of "a fair value for water," and in implementing this concept the government will endorse the concept of realistic pricing as a direct means of controlling demand and generating revenues to cover costs.

Traditionally, water rates have been based on the simple necessity of recovering the costs of supply and treatment (though empirical evidence suggests that those costs are seldom fully recovered).

According to Brooks and Peters, water has always been considered outside normal market conditions, different in nature than other commodities.[3] This has lead to an undervaluing of the resource which, in turn, has lead to underpricing of both water supply and sewage treatment services. The main consequence of this strategy has been that water has been overused.

This overuse has resulted in a number of negative effects, including the construction of costly and oversized water systems (over-emphasis on the supply side of the equation), and a deterioration in the quality of effluent discharged back into the environment (due to a lack of interest in demand management and proper sewage treatment).

The authors argue that by establishing a framework for assigning value to water, it will be possible to give it a price and subject its use to allocation and efficiency criteria applied to other commodities. This in turn will lead to changes in water consumption patterns.

However, they also warn that conventional valuation may be wanting, given that economic theory cannot account for all aspects of water's value, particularly water's amenity or recreational value. Nor does conventional economic theory address issues of social equity and fairness.

At present, Environment Canada is helping to fund a joint project of the Canadian Water and Wastewater Association and the Rawson Academy of Aquatic Science. The project is looking at the development and promotion of cost allocation methods and rate-setting strategies.

2.1.3 Public Awareness

The federal Policy correctly notes that changes in how individuals use water will require changes in individual attitudes towards the value and importance of water. Increasing public awareness to this end, then, becomes of paramount importance. Later in the report, the role of public education and awareness as a municipal initiative is discussed. Municipal agencies, with their mandate to supply and treat water, have a large stake in how efficiently the resource is used; in addition, municipalities are closest to the customer and, as such, can tailor awareness programs to local circumstances and needs.

This does not preclude the federal government playing a role in public awareness. Given their leadership role, the government could take the lead by developing a national water conservation strategy, including the setting of national water conservation goals and the establishment of a national advisory body for water conservation.

Environment Canada has already begun this process with the development of a paper — *Towards a Joint National Water Awareness Initiative*, 1988 — on a proposed water awareness program. The three-year program is designed to educate consumers about water, change their perceptions about water use, and inform the end-user about existing solutions. As outlined in the background paper, the initiative is largely media oriented, making use of television, video, print, and in-bound telemarketing (1-800 and 1-900 numbers) technology. The background paper also suggests other means of information and technology transfer, including: an annual National Water Day and ensuring the early application of the EcoLogo program to water-related products.

2.1.4 Other Initiatives

Muldoon and Saint-Laurent have identified a number of other initiatives open to the federal government.[4] They note that the government could play a small regulatory role in a number of matters ancillary to water conservation. For example, the federal government has prescribed emission standards for automobiles imported into Canada under the power given to it to regulate trade and commerce. According to Muldoon and Saint-Laurent, similar measures might be adopted with respect to plumbing fixtures and water appliances imported into the country.

The background document *Towards a Joint National Water Awareness Initiative*, 1988, suggests the need to build links with other federal agencies, provincial governments, industry associations, professional groups, and non-governmental organizations.

2.2
Provincial Water Conservation Initiatives

The *Constitution Act, 1867*, gives the provinces primary legislative authority over natural resources within their respective territorial jurisdictions. This includes authority over the regulation and distribution of water. Given these powers, provincial governments find themselves in the predominant position to develop and implement province-wide water conservation strategies.[5]

This section provides a theoretical framework for provincial action in regard to water conservation. Both limitations to provincial authority, and the opportunities at provincial disposal are examined in some detail. This section examines provincial programs that have put some of these various principles into practice.

2.2.1
Limitations

To date, no province has established a comprehensive water conservation program. Initiatives in this vein have been short-term in nature, and fragmented in coverage. A number of factors have been cited which, in part, explains the lack of provincial direction: the diversity of uses and user needs, a 'supply' approach to water management, a widespread lack of awareness of the need for water conservation, and a lack of coordination between the numerous agencies which have some authority regarding water distribution.

Nor does the Act provide specific direction with regard to water conservation. As such, it is necessary to seek implied intent in the wording of the various Acts and Statutes that transfer power to the provinces.

Finally, the provinces do not possess a completely free hand when it comes to the regulation and distribution of resources. The federal government also maintains certain legislative powers, and, where there is a conflict, federal legislation will take precedence over provincial legislation.

2.2.2
Opportunities

In addition to legislative authority over water resources, the provinces maintain authority over the instruments they have created to manage water resources — regional governments, municipal governments and utilities. This provides the provinces with a number of means and mechanisms for the promotion of conservation, including:

- *Terms and Conditions for Water User Permits*
- *Agreements for Municipal / Provincial Projects*
- *Conditions of Planning Approval*
- *Building and Plumbing Codes*
- *Education and Research*

Each of these mechanisms is discussed briefly below.

Terms and Conditions in Provincial-Municipal Dealings

Given the provinces position with regard to municipal authorities, the provinces are in a position to attach certain terms and conditions concerning water conservation in their dealings with municipalities.

Water Withdrawals: Pricing

The provinces' general legislative authority over natural resources may allow them to impose a water-use charge on withdrawals by large users. For example, Muldoon and Saint-Laurent note that in Ontario, the Ontario Water Resources Act gives the Ministry of the Environment the authority to impose terms, such as payment for use, on certain water users.[6] While the legislation was not drafted with water conservation in mind, it could, subject to certain exemptions, be used to that effect. Municipalities could be charged for quantities of water consumed — costs that municipalities would be forced to recoup through charges to municipal users.

In a similar vein, municipalities could be made to pay effluent charges, again, recouping those monies through charges to municipal users.

Water Withdrawals: Permits

Provinces may also be in a position, prior to the granting of permits for direct water withdrawal, to demand that municipalities pass water conservation by-laws.

According to Muldoon and Saint-Laurent, it is common practice in some American states to limit water drilling, taking, or other water uses to those who have demonstrated that they have taken low-cost conservation measures into account.[7] In the State of Illinois, for example, measures include the metering of all new construction and the adoption of ordinances requiring the installation of water-efficient fixtures.

Agreements and Approvals

Where the provinces enter into financial agreements with municipalities regarding water and sewage works, or where the provinces must give approval over those works, there may be leeway for the province to require water conservation measures before agreements or approvals are ratified.

Agreements for Provincial-Municipal Projects

Where provinces enter into agreements to finance water and sewage works, water conservation requirements and incentives may form part of that agreement.

Conditions of Approval

Similarly, the provinces may be in a position to require that water conservation measures be a condition of approval prior to the expansion of municipal water works systems.

Grants and Subsidies

It may be feasible to attach certain terms and conditions on grants and subsidies given to municipalities for environmental reasons.

Conditions of Planning Approval

Where official plans and draft plans for subdivisions must be approved at a provincial level, there may be the potential for the provinces to attach certain conditions relating to water conservation prior to approval. Further, it may be in the best interests of the province (and the municipality) to formulate official plan policies which require consideration of environmental features, such as water quality and quantity.

Codes and Standards

Provincial plumbing codes, where they exist, deal primarily with requirements for plumbing appliances and fixtures, including location, construction, repair, renewal, or alteration, that depend on a plumbing system in order to be used. CSA standards, regarding materials used in plumbing, including pipes, fittings, fixtures, and materials, may be adopted by reference. Neither provincial codes nor CSA standards (to date) include a strict water efficiency dimension, such as the mandatory use of water conserving fixtures or other appropriate plumbing practices. Consequently, there has been little, if any, incentive for the development of water efficient fixtures and appliances.

The potential for plumbing codes to play a part in water conservation efforts, however, remains great. The revision of codes to include water conservation measures, such as the mandating of low-flow toilets and other water conserving fixtures, would have a significant effect on water consumption at a municipal level. This is especially true when one considers the amount of water used by the two most popular fixtures in the house — the toilet, which uses 40 per cent of the water consumed by the average family, and the shower which uses upwards of 35 per cent of the water consumed by the average household. Water efficient fixtures reduce water consumption of standard fixtures by approximately 50 per cent. (Along with the shower water, there is a strong potential for energy savings given that an average shower uses 70 per cent of household hot water in its flow.)

Plumbing code modifications are an approach that has been taken, with success, in the U.S. More than one-third of the American States have set standards for the water efficiency of various plumbing fixtures.[8]

Education: Public Awareness

Public education is of paramount importance to any initiative, this is particularly true of water conservation. This avenue could be pursued by all four levels of government.

Education: In-School

Educating tomorrow's consumers today, represents one of the best ways of ensuring the changes in habit and attitude that need to take place to ensure the longevity of water conservation initiatives.

Primary and secondary education is a provincial responsibility, administered by the provinces through municipally elected school boards. In addition, provinces are responsible for the development of curriculum, though they may delegate some of this function to local school boards.

The federal government is currently pursuing public awareness and educational initiatives with other levels of government. Some programs include:

- The development of a water and land curriculum for Ontario schools, with water conservation as a major component, in association with the Ontario provincial government.
- The federal government is working with the municipality of Ottawa-Carleton in the development of the 'Wise Use of Water' campaign. The first year of the campaign will target residential users, the second year will target commercial and industrial users, and the third year will target schools and the educational system.
- Metropolitan Toronto is seeking federal input in the development of a water efficiency program.
- In Middleton, Nova Scotia, four levels of government are involved in a pilot retrofit program.

2.3
Municipal Water Conservation Initiatives

Next to the provinces, municipal governments possess the greatest authority to establish water-conservation programs. Indeed, given the powers granted the municipality — in particular, the right to own and operate water and sewage works — local governments may be in the best position to implement initiatives which target residential consumers.

This section looks at a number of conservation mechanisms available to local governments. The section examines briefly, the legal framework which both limits municipal authority and provides them with the scope for action. The remainder of the discussion focuses on specific conservation mechanisms. These are explored in detail and related to experience in other parts of North America.

2.3.1
Municipal Overview

Municipalities are provincial creations. They do not possess any legislative powers of their own, exercising only those powers granted them by the province through various Acts and Statutes. It is through this transfer of authority that local governments have taken on the responsibility for the supply and treatment of water. These powers grant municipalities the authority to establish, own, and operate water and sewer works. It also gives them the authority to levy retail water and sewer charges. The responsibilities may vary according to the type of governing mechanism in place. For example, a regional municipality may assume the responsibility of establishing, owning and operating water and sewer works but relinquish other duties to the local municipality(ies).[9]

Limitations and Opportunities

Municipal governments find themselves in a unique position with regard to the conservation of water, as, there are both limitations and opportunities for municipalities to undertake water conservation initiatives. As a political body they are severely limited by the provinces granting them authority. They cannot make laws and, therefore, do not have the right to legislate water conservation measures beyond reactive lawn watering bans, which are often problematic, from an enforcement point of view. And, where they do have authority, their actions cannot supersede provincial regulations in the same area. For example, while a municipality may have the power to enforce certain aspects of the plumbing or building code, they cannot adopt standards stricter than those prescribed by the province. This limits the municipality from mandating the use of water-conserving fixtures beyond those approved by provincial codes and standards.

In addition, the specific wording of the various Acts which transfer powers to the municipalities will differ from province to province. It is that wording which will be the final limiting factor in determining just how much leeway the local government has for action. In general, however, the measures identified in this section will, to some extent, be open to municipalities across the country.

The water conservation opportunities identified in this section include: rate changes and metering, leak detection, incentives for the installation of water-conserving fixtures, by-laws and development agreements, and public education campaigns.

Which mix of these mechanisms will serve a particular municipality best will depend on a number of factors, including: projected population, per capita consumption, and the split between industrial, commercial, residential, and agricultural water usage. As always, the success of a program will depend on proper planning, in particular, reliable estimates of current and projected water demands.[10]

Short-term vs. Long-term Measures

Water conservation initiatives can be thought of as short-term and long term. Short-term measures are responses to emergency situations, transitory in nature. They generally involve restrictions on outdoor water-use, such as designated watering times during the day, even-odd watering days, and even outright bans on exterior water-use. Such measures require a great deal of public cooperation, and are difficult to enforce over time. Short-term measures will not be considered in this report.

Long-term measures, once implemented will continue to provide sustained water savings for as long as the measures are in place. While public understanding is important, many of the measures are 'hardware' solutions, and do not rely on actual public participation. Municipalities whose experience lies in initiating short-term measures will find that long-term measures require a different approach to design and implementation, when the following items need to be considered:

- careful design and planning using the experience of others,
- benefits and costs need to be evaluated over a period of years, not months,
- pricing should reflect the social marginal cost of water, and must cover system expenses while encouraging conservation,
- the political, social, and technical feasibility of water conservation measures need to be realistically addressed,
- availability of durable, maintenance-free products,
- public awareness is essential to the success of a water conservation program, and
- interim feedback, monitoring and evaluation is as important as implementation.

Finally, while a residential water conservation program focuses on residential water use, other sectors, in particular government, are very visible water users and need to set a good example. Many of the strategies for reducing water use discussed here can find similar application in other sectors.

2.3.2 Municipal Initiatives and Implementation

The long-term water conservation initiatives covered include:

- *Pricing Structures*
  U.S. experience suggests that restructuring water rates to reflect the real cost of water leads to significant reductions in residential use. Given similarities between water-use practices (and the similarity of commercial and residential water-using products) between the two countries, restructuring of water rates should have a similar impact in Canada. Modifications to water rates demand careful planning in conjunction with an effective public education campaign.

- *Metering*
  Metering goes hand in hand with price increases. Any system for charging per unit of consumption requires measurement. Meters appear to be the tried and true method. There is also some empirical evidence that simply installing meters can cause a reduction in water use without any price increases.

- *Leak Detection and Repair*
  Another measure that should be given serious consideration, leak detection and repair causes minimum disruption to the service, and can be very cost-effective.

- *Public Education*
  Public education, as a stand-alone measure, will not yield large reductions in water use. However, it is considered by most experts to be crucial to the success of urban water conservation programs. For example, to prevent changes to water rates being met with resistance, customers need to know exactly what's involved and what's at stake.

- *Give-aways of water-saving devices*
  Municipal governments may not be in a position to legislate the use of water-conserving devices and fixtures, however, they are within their rights to promote the use of such devices through give-aways and financial incentives.

In addition to legislative authority, the measures listed above have all proven successful in numerous applications throughout North America. Other initiatives that are not backed by a large body of precedence, but may hold potential in the right situation, are also discussed. In no particular order, these include:

- *Development Agreements*
  Municipalities do not have the right to legislate the use of water-saving fixtures and devices. However, they may be able to affect plumbing fixture choices through by-laws and the planning approvals process.

- *Reduction in Water Pressure*
  Limited experimentation with the effects of decreasing water pressure has been carried out by several American cities. Results are not entirely conclusive, but it would appear to hold potential as a water saving measure for new developments.

- *Water Reuse*
  Water reuse holds relatively untapped potential for many Canadian communities. Cultural concerns, and concerns of health authorities will have to be overcome. Related to the reuse issue is the growing interest in stormwater management, via holding tanks and settling ponds, which can more proactively influence the rate and amount of stormwater entering either sewage treatment plants or ground water recharge areas.

Pricing Structures

The adjustment of water rates to encourage conservation has proven to be a successful, if somewhat controversial, method of reducing water use. Questions tend to focus on the following issues:

- what rate schedule is best;
- how much of a price increase is necessary to encourage conservation;
- will reduced demand allow the utility to cover costs; and
- how will issues such as social equity be affected.

Rate Schedules

A rate schedule is the schedule of charges levied by a municipality as the basis of water charges to consumers. A 1987 study by Environment Canada of 470 municipalities identified over 1100 individual rate schedules in use. These schedules were, in the main, variations of four traditional rate structures.[11]

- *Flat rate*
  The flat rate is the most common type of water rate used in Canada. Under this schedule, a fixed charge is levied regardless of the volume of water used. Flat rates provide no incentives for water conservation, because the price of each additional unit of water consumed is zero.

- *Declining block rate*
  The declining block rate is the most common type of volume-based water rate. Charges are successively lowered for set volumes (blocks) of water as consumption increases. Far from promoting water conservation, declining block rates actually reward inefficiency.

- *Constant unit rate*
  Under a constant rate schedule, the consumer pays a fixed price for each unit (e.g. cubic metre) of water consumed. A constant unit rate provides an incentive to conserve water because the bill to the consumer increases with the volume consumed.

- *Increasing block rate*
  An increasing block rate is the reverse of the declining block rate. In this case, charges are successively increased for set volumes (blocks), as water consumption increases. This schedule may provide the best incentive to conserve because the price increases as consumption rises. Less than 2 per cent of Canadian municipalities use this form of rate schedule.

Among other salient findings, the 1987 Environment Canada study revealed that:

- More than 70 per cent of rate schedules provided either no financial incentive to conserve water (flat rate), or a decreased incentive to conserve water (declining block rate).[12]

- In general, rate-making practices fail to recover the costs of providing water. The main criteria in setting rates appears to be acceptability to local ratepayers, accompanied by varying concern for cost recovery.

Price Increases

The effectiveness of pricing in reducing water use is shown through the concept of price elasticity. Price elasticity is the ratio of relative change in commodity use to the relative change in price. For example, if a ten percent increase in the price of water results in a two per cent decrease in indoor water use, then the price elasticity of inside water use would be –0.2.

Several studies indicate that, in practice, indoor water use typically has a price elasticity of around –0.24; and outdoor water use typically has a price elasticity of around –0.4.[13]

According to Brooks and Peters a parallel can be drawn to the early days of energy conservation.[14] At that time, similarly low figures were reported, but as more ways and means for conserving became available, elasticities rose as well — in some cases up to –1.0.

Recovery of Costs

Theoretically, water and sewer plant operating costs are paid for through charges to consumers. One of the major concerns expressed by municipalities is the possible reduction in operating revenue as a result of reduced water consumption.

The concern would appear to be invalid for two reasons. First, as Maddaus, 1990, notes, if water conservation programs are successful, then utilities will have lower operating costs because of reduced wastewater flows, and reduced energy and chemical costs associated with treatment.[15] As a consequence, the utility will require less revenue to cover lower operating costs; although they will have certain fixed (overhead) costs which are independent of wastewater volumes treated. Secondly, operating costs and revenues do not balance in reality under current conditions. In a 1985 report on water systems prepared for the Federation of Canadian Municipalities it was noted that only 82 per cent of water supply, 85 per cent of water distribution, 50 per cent of sewage collection, and 65 per cent of wastewater treatment costs were currently being covered by the user charges collected through water rates.[16] The remainder coming from lot levies, general property taxes, transfers from other levels of government, and increased debt.

It would appear then, that consumers are already shielded from directly assuming the full costs of maintaining water systems and consequently do not appreciate the 'real' cost of water.

Social Equity

As water rate structures begin to change to accommodate principles of full-cost accounting and marginal costs, care must be exercised on the part of the policy makers and rate specialists to ensure that the impacts associated with these changes are shared equitably by all income classes. In particular, people on fixed incomes must be protected from price increases which might lead to any further erosion of their standard of living and purchasing power. This group tends to be the one with the least amount of disposable income to allocate to discretionary uses. However, by default, they already tend to limit their water use to the lower blocks of the rate structure.

Billings and Day (1989) have shown that increasing block rates — wherein the marginal rate increases in each successive block — along with decreasing standard hook-up charges, not only generates a water conservation benefit, it is also more equitable because it forces higher income groups to shoulder more of the cost burden implicit in increasing block rates.[17] This is only fair, however, because this income group tends to be the one which uses more water per household.

Ironically, Billings and Day (ibid.) indicate that high-income households are the least inclined to cut back on water use. In fact, these households have relatively low price elasticities, which suggests that something other than the price mechanism will have to be applied to this group of consumers to ensure that they conserve a "fair share" of the resource.

Conclusions

Adjusting water rates can reduce water use, particularly if the following conditions are met:

- water rates reflect the real cost of water;
- water rates are related to the amount used; and
- water rates are increased enough to make customers lower their water use to a desired level.

Metering

With the exception of flat rates, in order to levy a charge on water consumption, it must be possible to measure the amount of water being consumed. In Canada, water is metered extensively, but in many cases the metering only applies to industrial and commercial consumers. Many municipalities meter a small sample of residential customers (typically 1 to 10 per cent) so as to determine 'appropriate' flat rates.

How much water consumption can be reduced due to metering is open to question, but the answer appears to be, significant amounts. Maddaus points to the Residential Water Conservation Projects — Summary Report, prepared for the U.S. Department of Housing and Urban Development (HUD), which suggests that water savings from metering can range from a low of 13 to a high of 45 per cent. Most of those studies were conducted between 1955 and 1975. More recently, data gathered by the Denver Water Department in 1981, 1982, and 1983 showed that metered households used almost 20 per cent less water than unmetered households. The savings ranged from 2 per cent in the winter to 25 per cent in the spring and summer.[18]

There is also some empirical evidence that metering causes a reduction in water use even without price increases. The city of Edmonton, which meters all residential users, consumes half as much water as Calgary, which is only partially metered. Those parts of Calgary that are metered, however, show rates of use similar to those in Edmonton.[19]

The Costs of Metering

Metering can be a costly undertaking. By most accounts, however, it is generally a cost-effective measure, with a consequent payback through the millions of dollars in infrastructure costs that can be avoided.

It has been estimated that meters will be cost-effective if they can be installed for less than $650.00 each. The Ontario Ministry of Natural Resources' *Towards a Water-Efficient Ontario: Phase I Options* report estimates that it would cost $350.00 per household for meter installation in Ontario.[20] The report goes on to say that the estimated total expenditure of $335 million to convert all water users in Ontario would still be cost-effective given that the initiative would avoid, or at least delay, the costs of construction for additional water and sewage plant infrastructure.

The City of Toronto is actively pursuing a policy of universal metering under its Water Conservation Programme.[21] The Programme calls for:

- mandatory metering of all new and existing buildings that have the water service within the street allowance repaired by the City and at the City's expense, or have the water service on private property or the internal plumbing in the basement replaced by the property owner; and

- a free of charge programme to retrofit existing residential buildings with water meters on the basis of public cooperation.

The Water Conservation Programme Report estimates that the average cost to retrofit existing buildings with a water meter is $350.00. (The report does not give an estimate for outfitting new buildings with water meters. However, it's important to note that installing meters in new homes, at the time of construction, is significantly less expensive than installing meters in retrofit situations.) The total cost of installing meters was estimated at $37 million in 1990 dollars.

The report notes that the price appears high. An extensive cost-benefit analysis — taking into account the cost of meter installation, meter maintenance, meter reading, predicted reductions in water consumption, and savings in the cost of operating water distribution and treatment facilities, as well as sewage collection and treatment facilities, and the future capital requirements for the expansion of these facilities, — was carried out for three different scenarios. The scenarios assumed different rates in reduction in water demand due to full metering. In all three cases, the economic benefits of universal metering outweighed the cost (capital, operating, and consumer surplus).

Leak Detection and Repair

It has been estimated that "waste and unaccounted-for water in metered systems ranges from 10 to 30 per cent of the total water entering supply-line systems."[22] Unaccounted-for water refers to water lost to underground leaks, illegal connections, reservoir evaporation and seepage, meter inaccuracies, and unmetered uses such as fire fighting. Losses can be significantly reduced by a leak-reduction program. Such programs are estimated to reduce water use anywhere from 1 to 9 per cent. It's also important to note that U.S. studies have indicated that leakage is not related to the age of the system.

A leak reduction program is a three-step operation.

1. A water audit to identify the need for a leak reduction and repair program.
2. Implementation of a leak detection and repair program.
3. Improved system maintenance and rehabilitation program.

Many municipalities do not undertake leak reduction and repair programs because of the perceived high cost. Grisham and Fleming cite work by Flack, Weakley, and Hill, which found, through a survey of 91 systems, that it is cost-effective to repair leaks greater than 7 m^3 per day per km. of water main.[23]

In addition, a leak reduction and repair program can reduce property damage; preventing leaks from undermining roads and other structures.

Of course, preventive maintenance is the best insurance, preventing leaks from occuring. Proper water-main design and installation coupled with a rigorous maintenance program are essential.

Public Education Programs

Water reduction of about 4 to 5 per cent is typical in most public education programs.[24] More important than the savings would appear to be public acceptance of, and cooperation in achieving long-term water conservation goals. The installation of water-saving devices, for example, depends entirely on customer cooperation, as does water reduction successes when changing rates.

Another primary goal of a public education program is to develop a conservation ethic in the consumer. Most consumers have a limited understanding of the steps a municipality takes to provide potable water and to treat wastewater. A public education program informs consumers about the 'urban water cycle' of purification, delivery, and sewage treatment: the costs of the service, the need for water conservation, the role that individual consumers can play, and the benefits that accrue to the consumer and the community from adopting a conservation ethic.

A variety of vehicles can be used to deliver a public education message. Some of the most common include messages on bills, articles, announcements in the media, the distribution of booklets and posters, and education through workshops. The most successful programs are those that are theme based, designed for, and aimed at a specific target audience, and conducted as an on-going program.

In-School Education

Long-term results in eliminating wasteful water-use habits can be best achieved by educating tomorrow's consumers — young people. Teaching children the value of water, and how to use it wisely will help instill a life-long conservation ethic. The best place to present this type of program is in the schools. According to Maddaus, in-school water conservation programs tend to focus on the fourth to sixth grade.[25]

Amongst the states, California is the acknowledged leader in promoting water conservation through the school system. The California Department of Water Resources (CaDWR), in Sacramento, California has even published a guidebook on starting a water conservation program for a student body, entitled: How to Do An In-School Education Program.

The American Water Works Association has published a complete school program, available to members through its Denver office. The AWWA, in cooperation with various utilities is developing a water-education computer program for in-school use.

In Canada, the Windsor Utilities Commission, in Windsor, Ontario has developed a water education program targeted at students in the fifth grade. The course is offered as part of the established science course curriculum and involves two in-school presentations followed by a plant tour.[26]

The course material is intended to enlighten students about water production, and enhance their knowledge of water conservation practices. The course is offered to approximately 2,400 students at 74 different schools.

Similar educational programs are now in place or under development in numerous other municipal and provincial jurisdictions. For example, the Ontario Ministry of Natural Resources and Environment Canada have jointly announced their intention to develop a water efficiency curriculum supplement for grades 1 to 6. It is expected to be ready for application in September, 1992.

Give-aways of, and Subsidies for, Appliances and Devices

In general, municipalities also have the authority to hand-out water saving devices, to provide subsidies to consumers, and to offer rebates and credits, usually as part of a wider plumbing retrofit program.

Programs involving the give-away of low-flow plumbing fixtures (low-flow showerheads, faucet aerators, and toilet dams or displacement devices), have been initiated across the U.S. in recent years (see Section 2.4 for a description of three U.S. case studies). These programs sometimes require the consumer to install the equipment, and sometimes involve a free installation by municipal staff. These programs, for the most part, appear to be popular, successful in reducing water use, and cost-effective. Appendix C (pages 96 to 99) contains a chart which lists a number of these programs, detailing the type of promotional campaign, the devices supplied, and estimated water savings.

Two more recent examples of retrofit programs are outlined here.

In 1986 the South Brevard Water Authority in Florida undertook "The Water Wise Home Program". The program involved a free water audit (including a toilet leak check), and the free installation of toilet tank dams and aerators in showerheads and faucets where the flow exceeded 13.5 litres (3 gal) per minute. Over 20,000 homes, apartments, and businesses participated. The average unit reduction in water use was 63.5 litres (14 imp. gal.) per day. This has freed an additional 7,300 m^3 (1,610,000 imp. gal.) of water without expansion of treatment facilities. With rapid growth being experienced by the area, the water conserved allowed an additional 5,300 new connections to the existing system.[27]

In 1988, the Massachusetts Water Resources Authority (MWRA), was experiencing a level of water use that exceeded the system's safe yield by more than 10 per cent. With the residential sector accounting for 38 per cent of municipal water use, household retrofit became a major component of a strategy to reduce water use. A pilot program provided, free of charge, low-flow showerheads, faucet aerators, and toilet displacement devices to a sample group of 15,000 residences.[28]

The success of the pilot program led to a decision to implement a system wide program (which was to begin in the summer of 1990), covering all 730,000 households. Implementation has been projected to cost US$20 – $25 per household. Based on annual operations, management and amortized capital costs per million U.S. gallons, the system-wide retrofit program is expected to be a ten million dollar investment, yielding a savings of 20,000 to 45,000 m^3/day.

In mid-1990, the City of Waterloo (population 79,000), just west of Toronto, was provided with free retrofit kits from the Region of Waterloo, via funding assistance from Ontario Hydro. The kits, distributed over the October 1990 to April 1991 period, contained one water efficient showerhead, two sets of toilet dams, three faucet aerators, flow restrictors (if needed), a roll of teflon tape, detailed instructions and a questionnaire. The kits (approximately 16,500) were distributed door to door by community groups and/or city staff.[29]

The final results are pending, but it appears as though properly retrofitted homes can experience an overall 13 per cent reduction in water consumption.

In 1981, the council of the regional municipality of Waterloo approved a region-wide rebate program which offers a $75 rebate per living unit to any plumbing contractor who installs water-saving fixtures in newly constructed residential units.

The rebate program was not actively marketed until 1985. It grew in popularity from a less than 9 per cent participation rate (1982), to in excess of 40 per cent in 1990. As of January 1, 1991, the rebate program has been discontinued, the rationale being that enough momentum has been achieved to sustain this aspect of water efficiency.

By-laws and Approvals

Muldoon and Saint-Laurent have identified a number of subsequent mechanisms available to municipalities to encourage water conservation.[30] While their discussion is based on an Ontario context, additional research suggests no reason why many of the same strategies could not be explored by other provinces.

By-laws

Local governments in charge of public utilities and regional governments in charge of distribution have the authority to make by-laws to limit water use within their territorial jurisdiction. For example, municipalities can pass by-laws restricting lawn watering, automobile washing and other non-essential activities.

In Ontario, the Planning Act provides that municipal zoning by-laws may authorize increases in the height and density of a development in excess of those permitted by the by-law in exchange for "facilities, services or matters as are set out in the by-law." This offers those municipalities with delegated powers under the Act, the opportunity to positively influence the water-use characteristics of new development.

Approvals

In Ontario, official plans are developed by municipalities and approved by the Ministry of Municipal Affairs. While it is not, in general, current practice, policies at both those levels of government could be formulated to require consideration of environmental impacts on natural resources, including water, throughout the planning process.

In addition, municipalities may indirectly influence subdivision plans by means of the plans they refer to the Minister and the recommendations which accompany them.

Reduction in Water Pressure

Pressure reduction reduces water usage and leakage, and cuts down on maintenance costs for the system. In general, pressure in municipal areas need be no higher than 345 to 420 kPa (50 to 60 psi) in the mains and 275 kPa (40 psi) inside a house. It is not uncommon, according to the literature, to find systems operating at pressures twice the minimum requirement.[31] Special valves, installed in the main, can effectively and economically reduce household water pressure at a cost of under $50.00.

A study of the effect on water use of a reduction in water pressure was carried out by the U.S. Department of Housing and Urban Development. Three different approaches were tried in three different cities. In Los Angles, California, water-use records were analyzed for an area where water use pressure was increased. In Atlanta, Georgia, a pressure-reducing valve was installed on the water main leading to a subdivision. And in Denver, Colorado, water use of homes under different water pressures was studied. Results indicate that water pressure and water use are indeed related. It was found that a decrease in water pressure of 30 to 40 psi leads to a decrease in use of by a factor of 3 to 6 per cent.[32]

However, reducing water pressure in already established areas may interfere with fire fighting capabilities and customer irrigation systems based on the original higher pressures. Water pressure reductions might be a strategy employed in new developments. See also Section 3.1.5 for additional information on pressure reduction valves.

Water Reuse

Water reuse is a viable, though somewhat unexplored alternative in a Canadian context. In the U.S. a number of communities use sewage effluent to irrigate parks, golf courses, and other recreation areas. A study for Hobbs, New Mexico, indicated that the use of sewage effluent to irrigate public facilities would save one year's supply every 16 years.[33]

Savings would not be as impressive in Canada, due to the relatively short growing season.

Water reuse for fishing, swimming and drinking, while technically feasible, still appears to be culturally unacceptable. Dual plumbing or greywater systems — water reuse on an individual residential basis is covered more fully in Section 5.

Where communities are considering reuse of surface water, detailed studies of the effects on downstream users will have to be undertaken.

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4. Paul Muldoon and Carole Saint-Laurent
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   The Canadian Institute for Environmental Law and Policy
   July, 1990

5. This discussion is based largely on work carried out by Muldoon and Saint-Laurent in their report *Turning Off the Tap: Water Conservation Law in Ontario* for the Canadian Institute for Environmental Law and Policy. Under the assumption, that while the names and wordings of various Acts will change from province to province, but the law will remain the same, many of their conclusions have been postulated to hold true outside of Ontario.

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15. Maddaus, op. cit. (note 10)

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18. In the Denver study, a relationship was developed between the monthly water used outside the home per unit of irrigated area and the monthly net evapotranspiration (ET). This relationship showed that the higher the net ET, the greater are the savings that can be realized by metering. This relationship will be useful to those wishing to extrapolate the Denver results to other cities having different ET patterns. For example, in humid areas where the net ET is lower than in Denver, water saved by metering can be expected to be less than 20 per cent, and conversely, for more arid areas where net ET is higher, the savings will be greater than 20 per cent.

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2.4
U.S. Experience

2.4.1
Plumbing Fixture Retrofit: Three U.S. Case Studies

A number of cities and water suppliers in the United States have or are in the process of developing plumbing fixture retrofit programs to reduce indoor residential water use, both for single- and multiple-family dwellings. Retrofit programs are one of the most common conservation measures employed because the water savings that they generate are usually immediate and, it is assumed, permanent and therefore result in lasting water reductions. Most of the retrofit programs to date have occurred in the West (California, Phoenix, Arizona, and Seattle, Washington), although a number of other regions of the U.S., such as the Northeast and the state of Florida, are now actively developing retrofit programs at this time.

Plumbing fixture retrofit programs are usually targeted to pre-1980 single- and multiple-family housing units. Retrofit of pre-1980 housing stock is usually preferred since most U.S. state plumbing codes changed around 1980 and began to require more water-efficient toilets, showerheads, and faucets at that time. Thus, the water savings achievable from pre-1980 housing stocks is higher than the post-1980 homes. The water savings associated with each fixture type for the pre-1980 and post-1980 periods is illustrated in Table 1.

The typical contents of a fixture retrofit kit include:

- Low-volume showerhead(s), using from 9.5 to 11.4 litres per minute (lpm) at 80 pounds per square inch (psi);
- Toilet displacement device(s) or dam;
- Low-volume faucet aerator(s), using from 7.6 to 9.5 lpm at 80 psi;
- Toilet leak-detection dye tablets; and,
- Instructions for kit installation and other water conservation information

The contents of retrofit kits vary, and some programs do not include faucet aerators since they are less cost-effective than the other devices in terms of the water savings they generate.

There are several methods of kit distribution, and each one is associated with varying ranges of participation and installation rates among targeted populations. The mass mailing of kits to targeted residential customers in a service area have a lower participation rate than the canvass (door-to-door delivery with in-person follow up checking and assistance) and direct municipal installation methods.

Toilet Water Use litres per flush	Water Use*		Water Savings**	
	Per Capita	2.7 Person Household	Per Capita	2.7 Person Household
Proposed 5.7	22.8	61.6		
Post-1980 13.3	53.2	143.6	30.4	82.1
Pre-1980 20.9	83.6	225.7	60.8	164.2
26.6	106.4	287.3	83.6	225.7

** assumes four flushed a day per person (does not include water use through leakage

Shower Water Use litres per min MFC	Water Use**		Water Savings	
	Per Capita	2.7 Person Household	Per Capita	2.7 Person Household
Proposed 9.5	31.2	84.1		
Post-1980 11.4 - 19.0	47.5	128.3	16.3	44.1
Pre-1980 19.0 - 30.4	61.6	167.2	30.8	83.1

** assumes a 4.8 min/d shower per person (actual savings with fixture replacements may be higher or lower because of averaging of water-use range)
*** stands for Maximum Fixture Capacity

Faucet Water Use litres per min MFC	Water Use**		Water Savings	
	Per Capita	2.7 Person Household	Per Capita	2.7 Person Household
Proposed 9.5	25.8	69.9		
Post-1980 11.4	30.4	82.1	4.6	12.3
Pre-1980 11.4 - 26.6	50.2	135.4	24.3	65.7

** assumes a 4.0 min/d running faucet per person (actual savings with fixture replacement may be higher or lower than shown because of averaging of water-use range for each faucet

All Fixture Water Use	Water Use		Water Savings	
	Per Capita	2.7 Person Household	Per Capita	2.7 Person Household
Proposed	79.8	215.5		
Post-1980	131.1	353.9	51.3	138.5
Pre-1980	207.1	559.2	127.3	343.7

Table 1: Potential Water Savings With Low-Volume Plumbing Fixtures
(Source: Vickers, Amy. AWWA Journal, May 1990)

* all measurements are in litres per day unless otherwise indicated

Since there has not always been consistent recording of field data to document the actual program participation (the number of customers accepting the kits) and installation or "penetration" (the number of customers who actually install some or all of the devices after the kit is received) rates for retrofit programs implemented to date, there currently exists limited reliable data on participation and installation rates. The approximate installation rates of retrofit devices for total households is shown in Table 2.

Device[2]	Mass Mailing	Depot	Canvass	Direct Install
Kit	15-40%	15-40%	50-80%	50-70%

1. Ranges illustrate low responses during non-crisis and high responses during crisis (i.e. drought or other water emergency) water conditions.
2. Kits include toilet-tank dams or bags, shower restrictors of low-volume showerheads, and leak detection tablets.

Table 2: Range of Installation Rates for Retrofit Kits[1]

Source: Water Conservation, by William O. Maddaus, American Water Works Association, Denver, CO., 1987

As more retrofit programs are implemented and evaluated using statistically-based analytical methods, it is likely that the participation rates associated with each of the distribution methods will be revised.

Effectiveness of Three Retrofit Programs

Three U.S. case studies of retrofit programs for residential customers were evaluated in this report for their demonstrated effectiveness. The programs and reports studied were from the cities of San Jose, California[1,2], Seattle, Washington[3,4], and metropolitan Boston, Massachusetts[5]. The San Jose program was the only completed full-scale program with sufficient data available to review the final results of a completed program. Both Seattle and Boston conducted pilot programs that are now being developed for system-wide implementation. The three programs were selected because they had the most documentation on program findings and they also represented different regions of the U.S. and thus were not biased to one particular area.

Data on water savings, financial savings and costs, and related program implementation considerations are shown in Table 3. A discussion of these program elements is discussed below.

Program Information	San Jose		Boston		Seattle	
	single fam.	mult. fam.	single fam. and mult. fam.		single fam.	mult. fam.
Year program completed	1988	1988	1989	1989	1989	1989
Program scale	service area	service area	pilot	pilot	pilot	service area
Installation method	canvass	direct install	direct install	depot	drop off & canvass	direct install
Households targeted						
goal	171,550	42,821	7,883	5,667	600	5 buildings
# actual installed **	113,193	33,552	4,556	1,500	404	534
% actual installation **	66%	78%	58%	26%	67%	100%
Customer water savings (gcd)						
showerhead	6.10		NA	NA	7.2	NA
toilet displace	0.70		NA	NA	2.1	NA
total	6.80	8.50	0 - 9.1	2.3 - 6.8	9.3	13.9
Utility's water savings (mcd)	2.9 - 3.2	0.6	NA	NA	1.33	0.017
Utility's program costs, $	$1,900,000	$434,800	NA	NA	NA	NA
Kit costs per household *						
delivered	$17.00	$13.00	NA	NA	$23.00	$8.10
$ cost of water per mgd saved	$1,500,000	$720,000	NA	NA	NA	NA

* costs are projected estimates for Boston and Seattle
** # and % actual installations = part or all devices installed
NA means data not available or no reliable data available

Table 3: U.S. Retrofit Case Studies Program Results
(source: Brown and Caldwell)

Kit Distribution Method

Each retrofit program utilized different kit distribution methods. San Jose used the door-to-door canvass system for single-family dwellings; multiple-family building managers/owners were given kits for installation that were later inspected by the city. Seattle tested both the canvass and drop-off (no follow up) methods for single-family homes, and multiple-family public housing units had devices installed by direct installation. The Boston pilot program tested both the depot and direct installation methods at their test sites.

Retrofit Kit Components

All of the programs provided low-volume showerheads rated from approximately 9.5 to 10.5 lpm and low-volume faucet aerators rated from approximately 5.7 to 9.5 lpm. Each program provided toilet bags or dams, with the exception of the Seattle program for public housing units which did not use displacement devices but instead repaired toilets that were leaking. As a result of the different approaches and devices utilized for each of the programs studied, the water savings and other program findings vary.

Water Savings

Each program reported different per capita water savings. The variations are likely due to the fact that each program provided or installed a variation of retrofit devices. For example, the Seattle program provided a number of extra faucet aerators to single-family households at the beginning of the program but less as it progressed. The devices installed for multiple-family households were split, whereby some apartment units had their leaking toilets repaired and others only had toilet bottles or bags installed.

The water savings for the San Jose and Seattle programs range from 25.8 to 36 litres per capita per day (lcd) for single-family households and from 32.3 to 52.8 lcd for multiple-family dwellings. The household savings for the Seattle program were higher than expected and may be attributed to the region's above-average public awareness and enthusiasm about environmental issues that resulted in higher installation rates for all devices.

The Boston pilot program reported 0 to 12 percent in water savings for direct installation participants and a 3 to 9 percent savings for depot participants. It had been expected that the pilot project would yield from 11 to 12 percent savings for fully retrofitted households. These savings represent approximately 5.7 to 31.9 lcd in combined savings for single- and multiple-family dwellings.

The low savings estimates for the Boston pilot program could be the result of many factors. Such factors could include: an abnormally low response rate; inadequate data collection and control; and, statistically invalid data. The Boston and Seattle studies also found variations in water savings by income levels, and the Seattle study found variations in water use and savings by age groups.

Program Implementation Costs

The costs to install the kits varied because each program utilized different installation methods, staff and consultant resources, and evaluation practices. The San Jose estimates for total program costs may be the most reliable at this time since their costs represent the implementation of a full-scale program that has been completed.

The total cost of the single-family retrofit were $1.9 million (all figures in this section are in US$), or approximately $400,000 for each million litres of water saved. This averaged about $17 per household. The costs for the multiple-family retrofit program was less, approximately $200,000 per mld and averaged about $13 per household. Multiple-family retrofit costs tend to be less than single-family households since they are usually installed by building managers/owners, thus reducing contracted labour costs.

The Seattle and Boston programs have not reported complete cost data for their pilot case studies. Seattle has projected that the cost to retrofit the 274,702 households (direct installation method) in its service area would be about $2.4 million for the drop-off method and about $3.1 million for the canvass method, or an average of $9 to $11 per household. The metropolitan Boston retrofit project, which is being sponsored by the Massachusetts Water Resources Authority, is projecting that the cost to retrofit 430,000 households (direct installation method) in its service area over a 3 year period will be approximately $12.4 million, or about $29 per household.

Program Cost Savings

The cost savings from the three programs, as represented by avoided operating (energy and chemicals) and capital expansion costs, have not been reported. The San Jose Water Department has estimated the the daily avoided marginal operating costs for each million litres of water saved is approximately $14.50.[6] Since it is not known what percentage of the devices installed during the retrofit program have been retained, it is difficult to accurately estimate the actual cost savings associated with the retrofits. Assuming that 50 to 85 percent of the devices are still installed, it is roughly estimated that approximately $30,000 to $52,000 in savings from avoided operating costs have been realized over the past three years.

Program Payback

Since cost savings for each of the programs studied have not been completely reported, reliable data on the payback for these programs studied is not available at this time. However, the Seattle Water Department has estimated that the payback period for the multiple-family retrofit program is about 10.5 months.

Installation Considerations

A thorough evaluation of the installation factors that should be considered in developing retrofit programs is beyond the scope of this study, but some general conclusions can be made from the three cases evaluated. Overall, the canvass kit distribution method had the highest installation and device penetration rate (over 70 percent). The Seattle study found that more water could be saved in multiple-family public housing units by repairing old leaking toilets than installing toilet dams or bags. The Boston pilot found a 58 percent participation rate for its direct installation method, and a very low (25 percent) participation rate for the depot method.

Public Reaction and Acceptance

Overall, most retrofit programs receive positive response from the public, as found in surveys of retrofit programs. It is assumed that the public is interested and willing to participate in a retrofit program due to a combination of factors: the devices are free and attractive and most people like to receive free items, especially when they are of value and constructed with good quality materials; hot water savings from the installation of low-

volume showerheads and faucet aerators will save money on gas or electric bills; water savings will (temporarily) reduce water bills and potentially help avoid or delay capital expansion costs for new facilities; and, saving water is good for the environment.

The level of local public awareness and enthusiasm about environmental issues may be a factor in boosting public participation in retrofit programs, as shown by the Seattle study. The Seattle pilot study found that the door-to-door drop-off and canvass methods had virtually the same participation rates, an unexpected finding. The drop-off method was originally expected to yield lower participation rates since participating households were not provided with face-to-face follow-up assistance (some say "prodding") by canvassers. The high response rate for the drop-off households indicates a high degree of public interest and commitment to conservation that does not require significant campaigning.

Demographic factors, such as age of persons in participating households, were shown to affect water savings in each of the programs. For example, the San Jose study found that children (age 10 and younger) use 31 percent less, a teenager (between ages 11 and 19) uses 29 percent less, and a senior (over the age of 65) uses 15 percent less water per capita than an adult.

Role of Incentives

The role of incentives in gaining public participation in retrofit programs, including their degree of impact, is difficult to measure at this time because it has not been broadly evaluated. However, for the retrofit programs studied, each had a primary reason for implementing their retrofit program that was conveyed in the promotional and outreach portions of the program. The San Jose program was primarily motivated to reduce wastewater flows and thereby delay a costly wastewater treatment plant expansion. The Boston and Seattle programs are motivated, in part, by the need to avoid system supply expansions that are politically unpopular and economically undesirable.

2.4.2 Low-volume Plumbing Fixture Legislation and Codes in the U.S.

Since 1988, more than eight states and numerous cities in the U.S. have either amended their plumbing codes or passed legislation to require low-volume toilets, showerheads, faucets, and urinals. The potential water savings associated with low-volume fixtures are shown in Table 1 on page 35, and the actual and potential savings have been documented.[8] A listing of the states that have passed such requirements, including their effective implementation dates, is shown on Table 4.

There are currently six states that are seeking adoption of laws to require water-use efficiency standards for plumbing fixtures and products in their jurisdictions, and a bill has been introduced into the U.S. Congress, the proposed *National Plumbing Products Efficiency Act* (H.R.843), that will be requiring water-efficient plumbing products and fixtures nationwide, similar to those values shown in Table 5.

State	Effective Date	Water Closets*	Urinals*	Shower-heads**	Lavatory faucets**	Kitchen faucets**
Calif.	1/1/92	1.6	1.0	2.75	2.0	2.5
Colorado	1/1/90				2.5	2.5
Conn.	10/1/90		1.0	2.5	2.5	2.5
	1/1/92	1.6				
Georgia	7/1/91	1.6	1.0	2.5	2.0	2.5
Mass.	3/2/89	1.6†		3.0		
	9/91	1.6††				
N.Y.	1/26/88		1.0			
	1/1/91				2.0	
	1/1/92	1.6				
Rhode Isl.	9/1/90	1.6†				
	3/1/91	1.6††				
Wash.	7/1/93	1.6	1.0	2.5	2.5	2.5

* gallons per flush
** gallons per minute
† 2-piece
†† all others (1-piece, back outlet, handicap toilets)

Note: all flow shown are in U.S. gallons

Table 4: States That Have Adopted Low-Consumption Plumbing Product Regulations

State	Effective Date	Water Closets*	Urinals*	Shower-heads**	Lavatory faucets**	Kitchen faucets**
Arizona	1/1/92	1.6	1.0			
	1/1/93				2.2	2.5
Delaware	1/1/91	1.6				
New Jersey	7/1/91	1.6				
Pennsyl.	1992	1.6		2.5	2.0	2.5
Texas	9/1/92	1.6	1.0	2.75		
Oregon	7/1/92†	1.6	1.0	2.5	2.0	2.5
	7/1/93††	1.6	1.0	2.5	2.0	2.5

* gallons per flush
** gallons per minute
† new residences
†† all others

Note: all flow rates shown are in U.S. gallons

Table 5: States With Low-Consumption Plumbing Product Regulations in Adoption Process

Most of the pending fixture bills have been introduced within the last year, with the exception of the federal bill in the Congress. The national plumbing fixtures bill was reintroduced in 1991 for the third time, and congressional hearings on it are expected sometime in the summer of 1991.

As can be seen from the maximum water use standards set for fixtures in Tables 4 and 5, there has been a general consistency in standards set for toilets, urinals, and kitchen faucets. The only exception to this is the City of Tampa, Florida. In 1990, Tampa passed a local ordinance to require low-volume toilets that use no more than 7.6 litres per flush (lpf), a concession to fixture industry lobbying efforts. Since most toilets either use less than 6 lpf or more than 13.3 lpf, most toilets installed under Tampa's new ordinance will likely use 6 lpf or less.

Some variations in water use standards have occurred with showerheads and lavatory faucets. The probable reasons for these variations likely include:

- legislators' beliefs or preconceptions about the public's willingness to accept lowered flow rates;
- varying success rates by the plumbing industry and conservation interests to lobby legislators to their point of view on what the standards should be;
- lack of knowledge about the availability of fixtures to meet lowered flow rates; and,
- local experience with previous conservation programs that distributed showerhead flow restrictors.

There is sometimes a negative public and utility attitude about low-volume showerheads if there has been previous experience with insert restrictors for showerheads, even though both are separate devices. Showerhead inserts have not produced significant water savings or public acceptance due to the reduced quality of showering that they provide.

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3.0
Canadian Residential End-Use Analysis

In Canada, approximately forty per cent of all municipal water is utilized for domestic (household) purposes. On a per capita basis, Canadians use an estimated 350 litres of water each day, just indoors. Domestic use can increase by 50 per cent during the growing season when outdoor use is factored into the equation. On a global scale, that places Canada second only to the U.S. in terms of domestic per capita water usage.[1]

The high per capita use can be attributed, in part, to ingrained water-using habits which have evolved over decades of seemingly endless water supply; and in part, to the inefficient, and ubiquitous, water-using fixtures and appliances typically installed in Canadian homes. For example, in terms of efficiency, the ratio of water to waste in a conventional flush toilet is 80 to 1.

This section deals exclusively with water-using fixtures and devices. It has been estimated that using only low-cost approaches, and less than state of the art fixtures, water use in a new residence could be cut from 30 to 50 per cent with no attendant changes in lifestyle. Those same approaches and fixtures in a retrofit situation, could reduce water use from 19 to 44 per cent.[2]

What follows is a general discussion of low-flow fixtures and appliances for reducing water use, both in and out-of-doors, currently available on the Canadian market. The discussion, for the most part, has been limited to readily available technologies, and those that have received approval from the Canadian Standards Association.

3.1
Indoor Water Use

Water use in a typical residential dwelling breaks down as follows.

- toilets — 40%
- showers and baths — 35%
- laundry and dishes — 20%
- cooking and drinking — 5%

To reduce indoor residential use, efforts should obviously be concentrated in the bathroom, followed by changes in water using appliances.

3.1.1
Water Closets

A conventional toilet uses about 20 litres (4.5 gal) of fresh water per flush. That can account for as much as forty per cent of all indoor water use. Water used for flushing can be reduced by up to one-half through various retrofit techniques. The installation of new low-volume toilets can reduce water used for toilet flushing by up to 75 per cent.

Toilet Retrofits

Toilet tank retrofit devices displace or otherwise reduce water used in the tank, but maintain the same head pressure (pre-flush water level), so that the water enters the bowl with the same force as it did prior to the retrofit.

Displacement devices can be home made (e.g. weighted plastic containers) or store bought (special bags with hangers). In general, these devices can displace about 3 litres (3/4 gal) of water without interfering with the flush mechanism.

A toilet tank dam isolates part of the tank, preventing the water trapped behind the dam from exiting with the flush. One toilet dam will hold back 4.54 litres (1 gal). Up to two dams can be installed per tank.

Alternative flush devices (AFDs) can reduce the amount of water used with each flush by up to 50 per cent, according to manufacturers' literature. The devices are fastened onto the overflow pipe in the toilet tank, and limit the height the flapper can rise. A variation on these early-closure mechanisms is the dual-flush device, which allows the operator the option of a partial flush when warranted, depending on how long the flush handle is operated.

No corroborating literature has been found to substantiate manufacturers claims.

Retrofit programs in several states in the U.S. have achieved dramatic reductions in residential water use through give-aways and free-installation of toilet retrofit devices. Several examples are provided in chart form in Appendix B. (The toilet devices represented one of several water-conserving devices provided to consumers. Figures for water-reduction specific to the application of toilet retrofit devices were not available.)

It should be noted, that in many cases, conservation benefits were not sustained over the long-term. It would appear than toilets designed to use 20 litres per flush do not perform as well when the amount of water passing through them is significantly reduced. This can lead to double flushing on the part of the consumer, or the removal of the device altogether. It is at this point that the advantages of some of the water saving devices become apparent. For example, if toilet dams are found to be saving 'too much' water, contributing to the need for double flushing, they can readily be adjusted to allow more water to be used per flush but still conserve water.

Water-Efficient Toilets

The installation of a new water-efficient toilet represents a permanent hardware solution that cannot be tampered with by consumers. The installation of a low-volume toilet could feasibly reduce domestic water use by thirty per cent.

Most major toilet manufacturers now market a low-consumption toilet that uses between 11 and 13 litres (3.5 gal.) per flush. Redesigned bowls and tanks account for the more effective washdown.

Low-volume toilets are also available. These use less than 6 litres (approx. 1.3 gal.) per flush. Low-volume toilets can use pressurized water, pressurized air, or an extremely well-designed tank and bowl system to induce a sufficient siphonic action for flushing the fixture.

With the pressurized water system, the toilet takes advantage of the pressure (40 to 60 psi) that exists in the water line, by means of a "flushometer tank". In a conventional toilet, water loses its pressure as it fills the tank. In a pressurized system, water enters a sealed vessel (the flushometer), compressing the air trapped inside until it equals the pressure of the supply line. When the toilet is flushed, water enters the bowl with a force up to 500 times greater than a conventional toilet.[3]

Some systems employ a separate air compressor that further aids the pressurized water. Compressed-air assisted toilets can use as little as 1 litre (0.25 gal) per flush, but some models are prone to be very noisy.[4]

Low-volume toilets that do not use water or air pressure, utilize tank and bowl design innovations. The Ifo Cascade, for example, splits the tank discharge into two streams of water, one on each side of the bowl. The resulting jet stream action gives the water increased velocity and force. It also creates a vortex which enhances the washdown action.

Municipalities in numerous American states (see charts in Appendix C) have mandated low-volume toilets in new construction. A proposed National Plumbing Efficiency Act, which would mandate a national plumbing standard restricting all new toilet installations to models using 6 lpf or water or less, is currently before the U.S. Senate and House of Representatives.

In Canada, lack of awareness of water issues in consumers has translated into a lack of demand for water conserving devices. Lack of a water conservation strategy at all levels of government has translated into federal and provincial building and plumbing codes which do not include provisions for water efficiency nor measures to encourage water conservation. As a result, there is little incentive for the development of water efficient fixtures and devices.

Accordingly, at present, few CSA-approved low-volume toilets are readily available in the Canadian marketplace. At the time of writing, only two low-volume toilets — in the 6 lpf

range — had received CSA approval under their "water conserving toilet" category, which allows a maximum flush of 13.25 lpf. A "water efficient" toilet standard — for toilets using a maximum of 6 lpf — is at the balloting stage within CSA at this time.

In addition, under the current CSA testing standards for water closets, the ability of many low-volume toilets in the 6 litre per flush performance range to pass the CAN/CSA B45 testing protocol is unknown. (Refer to Section 4.0 for a complete discussion of codes and standards issues.)

3.1.2 Showerheads

Conventionally engineered showerheads have flow rates up to 20 litres (4.5 gal.) per minute. Flow-restrictors (a washer with a small hole in the middle) have been used in the past to reduce the flow through conventional showerheads. Unacceptable shower performance has generally led to the removal of these devices.

Properly engineered low-flow showerheads, have shower rates between 6 and 10 litres (1.5 to 2.5 gal.) per minute, and are widely available. These showerheads are designed specifically to produce acceptable shower performance while reducing water-use.

There are two types of low-flow showerheads: aerated and non-aerated. Aerated fixtures reduce the amount of water in the flow, but maintain pressure by mixing in air. Non-aerated showerheads 'pulse' the water. Both types are reported to perform well.

In Amherst, Mass., a state-funded pilot program offered low-flow showerheads to a group of homeowners. Those homes decreased water use by 16.4 per cent. An apartment complex in the same town installed low-flow showerheads and reduced water pressure, and achieved a 33 per cent drop in water use.[5]

A 1991 study undertaken by the Ontario Ministry of Government Services, found that installing low-flow showerheads in a 719 unit apartment highrise, would reduce shower water use by 53 per cent. That in-turn would yield an annual savings of $22 357 in water and wastewater charges and an annual savings of $15 650 in natural gas for hot water heating; and a combined savings of $38 000. The capital cost for purchase and installation of the low-flow showerheads for this highrise have been calculated to be $16 537. The payback period would be less than one-half year.[6]

3.1.3 Faucets

Conventional kitchen and bathroom faucets average flow rates of 13.5 litres (3 gal.) of water per minute; far more water than, in most cases, is needed or can be used. Low-flow faucet aerators can reduce the flow rate by 50 per cent or more.

There is a need when utilizing faucet aerators to match the technology with the intended use. For example, bathrooms, where the major uses are washing hands and brushing teeth, have the lowest flow needs. A flow rate of 2 litres per minute will be sufficient. In the kitchen, flow rates of 6 to 9 litres per minute are required.

Leading edge technologies include the use of infra-red sensors which turn tap water on when they sense an object below the faucet, and turn tap water off when that objects is moved. These faucets, however, are significantly more expensive that standard tap technology.

The Delta Chelsea Inn in Toronto installed 1 000 low-flow aerators, reducing water use by 20 per cent. The capital investment of just under $13 000 was recovered in five months.[7]

The 1991 study undertaken by the Ontario Ministry of Government services, found that installing low-flow aerators in the kitchens and bathrooms in a 719 unit apartment highrise, would reduce water use by 33 per cent. That in-turn would yield an annual savings of $2 700 in water and wastewater charges and an annual savings of $1 890 in natural gas for hot water heating; and a combined savings of $4 590. The capital cost for purchase and installation of the low-flow showerheads for this highrise have been calculated to be $4 314. The payback period would be just under one year.[8]

3.1.4 Appliances

Clotheswashers and dishwashers can use a significant amount of water — more than 1 200 litres (266 gal) each per month, depending on use. At present, few "sudsaver" clotheswashers — wherein the rinse water from the previous load is used as the wash water for the next load — are available in Canada. In general, European appliances tend to be more water-efficient than their North American counterparts.

Front-loading clotheswashers, that rotate on a horizontal axis, are reported to use up to one-third less water than top-loaders. Front-loaders use water more efficiently because the clothes tumble through the water rather than settling in it. While popular in Europe, front-loaders have not been able to make a significant penetration into the North American market. One source claims that front-loading machines are unpopular in North America because they require the user to stoop to load and unload clothes.[9]

Hot-water heaters also come under consideration. Insulating hot water tanks and hot water pipes can reduce hot water use — the heated water stays at the desired temperature over longer pipe runs and longer intervals — and saves energy. Alternatively, point-of-use hot water heaters can be considered. They are located adjacent to the point-of-use, thus minimizing water (and energy) wasted while using hot water. Regardless of water heater type, the higher cost of energy relative to water, and the potential dollar savings associated with reducing hot water consumption, may offer the better incentive to reduce hot water consumption.

3.1.5
Pressure-Reducing Valves

An adequate water pressure for most residential areas is between 345 to 420 (50 to 60 psi) in the mains and 275 kPa (40 psi) inside a house. Anything higher than this is generally unnecessary and wastes water at sinks and showers. It is not uncommon to find systems operating at twice the necessary pressure.[18]

As noted in Section 2.3, a pressure reduction valve installed in the main water line can reduce both water usage and cut down on maintenance costs. There is some evidence, however, that pressure reduction does not significantly reduce water use. If residents find water pressures too high, they can adjust the flow themselves at the point of use. Pressure reduction appears to be primarily a tool used by property managers worried about tenants, who have no incentive to conserve, using too much water.

The Denver study cited in Section 2.3 noted that reductions in water use, through pressure reductions, may have resulted from reduced leakage. Many pipe joints may not have leaked under reduced pressure.

3.1.6
Home Water Treatment Systems

Currently home water treatment systems (HWTS) are unregulated. It is recommended that any system which modifies potable, residential water supply, be:

- classified as either a filtering device or an active treatment system;
- regulated/tested via the Ministry of the Environment or a similar agency for performance standards;
- documented in a comprehensive manual of HWTS, available through the Canadian Water Quality Association; and
- required to meet water standards identical to those for municipalities.

In general, water softener systems and water purifiers both use significant amounts of water. Softening systems, designed to remove calcium and magnesium from the water entering the house, can use in excess of 350 litres of water each time the softening agent is regenerated. Regeneration is generally manually set and occurs an average of 3 times per week.

Filtration systems remove impurities from drinking water. In doing so, much of the water that passes through the filter goes directly down the drain.

Sink garbage disposal systems consume hundreds of litres of water each week. Certain arguments have been made in favour of garbage disposals: they divert waste from overcrowded landfill sites; organic matter is more easily broken down in sewage treatment facilities than in landfill sites; and, that the additional nutrients provided by garbage disposals could actually be beneficial in a waste stream that contained too much water.

However, in regions where water shortage is a problem, sink garbage disposals would appear to be a hindrance as opposed to a help. Municipal compost projects may provide a better solution for the disposal of kitchen wastes.

3.1.7 Water Reuse

Water reuse, and the capture of precipitation as source of residential water supply are two relatively unexplored water conserving options. In this section we explore the potential for reuse of greywater. The reuse of rainwater is covered in section 3.2.3.

Grey Water Reuse

Greywater refers to water which has been used, but contains no sewage. Greywater may be recycled to provide a source of water for toilet flushing, but more commonly for garden uses.

The water that drains from bathroom basins, tubs, showers and laundry rooms is the best source for greywater. Water from kitchen sinks is also considered grey water. However, the fats, oils, and greases from dishwashing makes kitchen water hard to filter, and a more likely breeding ground for disease.

If greywater is to be recycled, there will need to be significant adjustments made to standard plumbing systems in order to capture the water and pipe it to its secondary use. In addition, greywater intended for re-use in a garden may have to undergo some form of pretreatment to remove contaminants.

There are restrictions on greywater use in many municipalities.

New water-efficient plumbing systems can offer water savings of 30 to 95 per cent over conventional plumbing. These systems include wastewater treatment and recycling systems; vacuum toilet systems; and pushbutton, single-line plumbing systems. However, no Canadian case studies exist to substantiate the claimed water savings and the products' availability in the Canadian market is very limited at this point.[11]

3.2
Outdoor Water Use

The majority of residential water use outdoors is dedicated to horticultural purposes. During the growing season, residential water use can rise by a factor of 50 per cent or more. A significant portion of outdoor water is wasted due to evaporation or run-off through over-watering and other inefficient watering practices.

In addition to quantity issues, landscape practices have an effect on water quality as well. The residential sector uses up to ten times more toxic chemicals (fertilizers, herbicides, and insecticides) per acre than the agricultural sector. Chemical run-off can seriously impact ground-water reservoirs, and add to the cost of water treatment downstream.

Outdoor residential water use can be significantly reduced through a knowledge of plant needs and effective watering techniques. This type of information should be an integral part of any public education campaign aimed at reducing water use in the residential sector.

Outdoor water use can also be reduced in ways that do not rely totally on public cooperation and consumer knowledge. Hardware, such as the watering equipment itself, can play a large role in determining how efficiently water is used.

Changes to the landscape itself, however, appear to provide the largest and most long-term water-use reductions. Low-maintenance landscapes, pioneered in the U.S. south-west, can reduce horticultural water use to zero — though a forty to fifty per cent reduction would be a more realistic figure in a Canadian context. Implementing landscape criteria that reduces horticultural water use appears to be well within municipal jurisdiction.

This section explores a range of water-efficient watering equipment currently available, and examines the principles of low-maintenance landscaping.

3.2.1
Watering Equipment

It has been estimated that 25 to 50 per cent of the water used for irrigation in a residential setting is wasted. It falls on non-garden areas, runs off because the flow is too rapid to be absorbed, or evaporates from the surface or in the air as it is sprayed.[12]

A knowledge of when, how, and how much water to apply to lawns and gardens could significantly reduce outdoor water waste. Unfortunately few gardeners have the time or inclination to acquire the proper know-how. Proper watering times can, however, be judged by mechanical means; and proper water coverage can be provided by more efficient irrigation equipment.

Meters and Conditioners

Moisture meters are available which measure soil moisture and determine when the soil is dry enough to warrant watering. Meters are planted at various locations around the yard; some need to be read manually before watering, others can be configured into automatic watering systems (see below).

Cathodic conditioners lower the surface tension of water, allowing it to percolate deeper into the soil. Manufacturers claim these devices can save 25 to 50 per cent of irrigation water depending on soil permeability. They are expensive, and require a plumbers assistance to install.[13]

Sprinklers

Conventional water sprinklers can lose between 25 and 50 per cent of their spray through evaporation, run-off, and application of water to paved areas. Watering systems that lay water down in a flat pattern are less prone to evaporative losses.

Drip-irrigation, however, is the most efficient and effective method of watering. Soaker hoses (a hose with microscopic holes that leak water at a constant rate) can cut irrigation losses in half. Soaker hoses can be laid on the surface or, preferably, buried beneath the ground where they supply water directly to the root zone of the plants.

Subsurface pipes that carry water directly to the base of each plant are also available. These are even more efficient than soaker hoses since the spaces between plants do not receive water.

Automatic Watering

Both sprinklers and drip irrigation systems can be hooked up to automatic, programmable watering systems. Automatic watering systems can be extremely water-efficient, automatically supplying the lawn and garden with water only when needed. A watering schedule can be computer programmed to complete a variety of tasks: provide additional water to turfgrass areas; water sloped areas, where run-off is a problem, on short on-off cycles; and to shut down during periods of rain.

Moisture sensors can work in conjunction with an automatic watering system, overriding the timer, making the system even more water efficient.

3.2.2 Landscapes

Landscaping is where the largest water savings can be achieved. A typical suburban lawn (approx. 350 square metres) can require up to 200 000 litres of water during the course of a single growing season.[14] A low-maintenance landscape, by comparison, could conceivably require no water inputs except that provided by nature through precipitation.

The concept of low-maintenance landscaping was developed in California where it is known as xeriscaping (desert landscaping). Based on successful application there, municipalities in various states have instituted landscaping laws aimed at reducing outdoor water use.

Principles

In principle, a xeriscape would require zero-water input. In practice, most municipal programs aim for a forty to fifty per cent outdoor water use reduction. While approaches vary, all programs have seven steps or principles in common: proper design and planning; reduced turfgrass areas; improvements to soils; proper plant selection making use of native grasses, shrubs, and trees; mulching; zones of low-volume irrigation; and planned maintenance.

The most significant savings come from a reduction in turfgrass area, and switching from more exotic plant forms to native species. In general, turfgrass areas should not exceed what is useful for social and play activities. And, to be useful, the lawn should be placed where the family spends the majority of its time — the back yard.

Native plant species require less water than non-native species. When planting, plants with similar watering needs should be grouped together to maximize watering efficiency.

Benefits

The first and foremost benefit of low-maintenance landscaping is a significant and permanent reduction in outdoor water use. In addition, low-maintenance landscapes, through the use of native fauna, are more resistant to insects and diseases. As a consequence, the use of fertilizers, herbicides, and insecticides are reduced, if not eliminated, in residential areas.

Proper landscape design can also beneficially alter microclimates and reduce building energy demands, especially in the summer when the need for air conditioning is at its peak.

Finally, ten per cent of the residential waste stream is generated through residential yard waste. A low-maintenance landscape could reduce the amount of yard waste entering municipal landfill sites.

U.S. Experience

Low-maintenance landscaping lends itself to considerable adaptation, depending on the municipal context.

The City of San Diego has designed a landscape zoning ordinance for all new construction throughout the City, with the exception of single family residential and agriculture. Regulations set specific percentage limits on decorative turf areas and areas incorporating the uses of water features.[15]

In 1980 a study of landscape water use in a planned townhouse/condominium development in Novato, California, suggested that landscape water requirements could be reduced by up to 40 per cent if certain criteria were met. The District pursued the suggestions, and undertook to compare, on a monthly basis over an entire irrigation season outdoor water use for a traditional and water conserving landscape. Seven planned unit developments (consisting of 548 units) were divided into two sample segments: traditionally landscaped projects and projects that met water conserving design criteria.[16]

The study found that developments whose landscapes are designed to meet the following criteria can expect to reduce landscape water requirements by up to 50 per cent:

- perimeter of turf must be less than 20 linear feet per dwelling unit;
- area of turf must be less than 500 square feet per dwelling unit;
- turf should be "pooled" into high visual impact and functional use areas on shallow or level slopes, and not used along long narrow pathways, in sidewalk strips, or along foundations of buildings;
- non-turf landscape area to be planted predominantly with water conserving plants available locally; and
- the irrigation system should be in-ground, and equipped with modern controllers and designed for at least 100 per cent overlap.

Low-maintenance landscapes do not have to be limited to residential areas. Government and commercial buildings that maintain lawns would also be likely candidates for conversion. A study by the Planning Department of the City of Arvada, Colorado, shows that in the right geographic location, low-maintenance landscapes adjacent to roadways are also viable.

3.2.3 Cisterns

One inch of rainfall will provide approximately 1.8 litres (0.4 gal) of water per square foot of catchment area. A cistern, which collects and stores rainwater, will capture as much as three-quarters of the annual rainfall on the catchment. Depending upon geographical location, rainfall could be a significant source of residential water supply. Cisterns have been used to capture rainfall for hundreds of years. They can be as small as a barrel, but are more commonly an underground tank, or room in a basement capable of holding large volumes of water.

Cisterns can be constructed from a variety of materials including, wood, brick or stone masonry. Ideally, they should be made of high-density concrete, vibrated as it is cast in place, and allowed to wet cure before being put to use.

Cisterns are an excellent method of storing water for an emergency situation. Cistern water can also serve as an active, everyday source of supply for gardening. However, because this water may contain algae, suspended sediment, and other particulates, it is not considered potable.[17,18,19,20]

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4.0
Codes, Standards and Regulations

This section of the report deals with a number of technical issues related to sanitary plumbing and water conservation. An attempt has been made to focus on areas of immediate concern. It is being assumed that the need for water conservation is real and significantly impacts urban infrastructure and housing development. The discussion which follows is therefore a representation of the opportunities and barriers to water conservation whose potential is not being reflected in codes and standards. The specific areas being presented are as follows:

- A comparison of current Canadian and U.S. plumbing fixture standards;
- A synopsis of standards harmonization, technical research and development;
- Impacts of low flow plumbing fixtures on the Canadian Plumbing Code;
- Impacts of low flow plumbing fixtures on municipal and private sewage systems;
- Plumbing Code enforcement issues relating to water conserving plumbing fixtures; and
- Conclusions and recommendations.

The discussion of each topic to follow recognizes that a number of standards govern sanitary plumbing fixtures. Only those aspects of standards dealing with water usage are being considered in this report Plumbing fittings and fixture finishes are viewed as being less critical to water conservation initiatives.

4.1
Comparison of Canadian and U.S. Standards

The two related standards which are being compared in this report are CAN/CSA-B45 Series-88, *CSA Standards on Plumbing Fixtures* and ASME A112.19.6-1990, *Hydraulic Requirements for Water Closets and Urinals*. Within these two standards, only the water closet performance tests are being compared.

The comparison of water closet performance testing within the two standards has been presented in the chart starting on the next page.

In comparing the two approaches to water closet performance, it may be concluded that the Canadian standard attempts to more accurately simulate the isolated fixture performance over a wider range of serviceability conditions, whereas the U.S. standard simulates installed fixture performance over a narrower range of serviceability conditions.

Test Parameter	Canadian Test	U S Test	Comparison
Solids removal	15.8.5 Carry-out capability	7.1.3 Removal of solids	CSA requires that a series of 4 tests are performed to simulate the various common solids characteristics to be removed. A minimum cumulative score based on an index of grade points for each test is required to pass. The U.S. method uses 2 tests simulating a narrower range of solids characteristics. Tolerances differ for the two tests ranging from 5% retained for granules to 25% for balls. As the Canadian and U.S. approaches do not share a common basis, only empirical comparison is possible.
Water exchange	15.8.3 Water change capability	7.1.5 Removal of waste liquids	The Canadian standard uses a visual measurement of a 1 to 500 dilution ratio based on the volume of the filled bowl. The U.S. procedure is based on an absolute minimum dilution ratio of 1 to 100. Due to variations in the filled bowl capacities, the Canadian test measures varying concentrations by requiring a relative rather than an absolute dilution ratio.
Bowl washing	15.8.4 Flushing surface	7.1.4 Washing of flushing surface	The Canadian test uses sawdust applied to a prewetted surface and the residue after flushing is counted. The U.S. test uses a line of water soluble ink applied to an air dried surface about the circumference of the bowl. No more than 2 inches of visible line is permitted after flushing. Both tests rely on visual inspection and contain their respective limitations.

Chart Showing Comparison of Canadian and U.S. Standards

Test Parameter	Canadian Test	U.S. Test	Comparison
Drainline transport	No equivalent Canadian test	7.1.8 Drainline transport character-ization procedure	The U.S. test involves flushing a number of balls down into a drainage line and measuring whether an average carry distance of 40 feet is achieved. This test is intended to determine the serviceability of the fixture when installed in the field. A comparable Canadian procedure has not been developed as the Canadian solids removal tests are premised on the assumption that if the fixture adequately transports solid waste in the laboratory it will continue to do so when connected to a conforming plumbing system.
Water volume	15.8.6 Flush volume	7.1.6 Water consumption and hydraulic character-istics	The CSA test procedure is only conducted for conservation-type water closets. An average of 5 flushing cycles must not exceed 13.25 litres per flushing cycle. The U.S. standard employs an average of 3 flushing cycles which must not exceed 6 litres per flushing cycle and no more than 7.6 litres in any 1 flushing cycle.

Chart Showing Comparison of Canadian and U.S. Standards (con't)

If the water volume used in the average flushing cycle to warrant a low consumption rating is a meaningful indicator, the Canadian procedures tend to demand higher flush volumes for an acceptable level of performance.

Neither of the two procedures are readily correlated to in-situ performance and hence it remains difficult to ascertain which, if either, of the two standards achieve acceptable performance when installed in the field. In terms of harmonization, this poses a difficult problem as the basis for determining equivalence is not found in either of the two methods.

The determination of equivalence will apparently require further research and development of procedures which will yield comparable indicators. These in turn will have to be correlated to actual, in-situ performance to conclude if the parameters being tested reliably result in the acceptable performance of low consumption water closets at the consumer level. Discussions with Ontario Plumbing Code officials indicate that few, if any, complaints regarding performance of low consumption water closets are registered by consumers. This tends to suggest that significant rethinking is needed in tomorrow's standards.

4.2
Progress in Harmonization, Technical Research and Standards Development

Based on the comparison of the two standards for water closet performance, this report now turns to a synopsis of harmonization, research and development activities.

CSA's investigation activities of water conservation hail back to the early 1980's. A task force discussion paper was issued by CSA in 1983 which pointed out that, "longer term benefits would come only from changes in building codes and standards." Consumer awareness was also identified as a primary barrier to effecting water conservation measures in practice. The discussion paper closes with a strong warning that the CSA Committees do not wish to change existing standards unless, "they, the Committees, can be shown that such changes are sound from a technical point of view and based on accurate knowledge and research."

Over the past two years, CSA and its U.S. counterpart have endeavored to develop harmonized standards. Given the reality of the Canada-U.S. Free Trade Agreement, this activity has been paralleled in other standards organizations and will likely continue. One of the issues arising from harmonization is the desire by manufacturers to submit to a streamlined, cost-effective testing procedure The manufacture of two distinct product lines, where standards differ significantly in their requirements, may prove prohibitive and result in the market with the more stringent requirements offering consumers a limited and possibly more expensive choice. At the same time, harmonization and standards research and development require capital resource which manufacturers are reluctant to subsidize.

It appears that this counterbalancing of interests has left technical research and development of a harmonized standard at an impass given the vested interest of manufacturers and the limited resources of CSA.

4.3
Impact of Low-Consumption Fixtures on the Canadian Plumbing Code

The impact of low consumption fixtures on the current Canadian Plumbing Code (CPC) are relatively minimal. The discussion which follows is based on the requirements as set out in the identified articles of the 1990 Canadian Plumbing Code. Without going into detail, it may be noted that low consumption fixtures do not in general impact fixture connections or supports and hence the discussion focuses primarily on water consumption.

Conformance to Standards (CPC Article 2.2.2)

Water closets are required to conform to the standards set forth in this article of the Code and it is therefore essential that low consumption fixtures meet the performance requirements within the listed standards. Code requirements do impact many manufacturers' products which do not pass the present performance requirements in the listed standards.

Hydraulic Loads for Fixtures (Article 4.10.2)

The hydraulic loads for fixtures noted in Table 4.9.A of the Canadian Plumbing Code list flush tank water closets as having an hydraulic load of 4 fixture units. This table will likely require either an additional listing for low consumption water closets or a supplementary calculation based on the actual flush volume. Depending on the building facility under consideration, lower hydraulic loading than normally results from standard water closets could translate into smaller pipe sizes. The resulting economy may prove significant.

Vent Stacks (Article 5.4.2)

The present limitation for vent stacks of a total connected hydraulic load not exceeding 8 fixture units (5.4.2.(3).(a)) will not be impacted by low consumption fixtures, however, low consumption fixtures will permit enhanced flexibility in vent piping arrangements than that currently permitted using standard consumption fixtures.

Location of Vent Pipes (Article 5.6.3)

Under sentence 5.6.3 (3) of the Canadian Plumbing Code, the fall and length of the water closet fixture drain are limited to a maximum of 1m and 3m respectively. This requirement may require investigation in the case of low consumption water closets.

Hydraulic Loads Draining to Wet Vents (Article 5.8.1)

Similar to the previous case, wet venting requirements in the Code will not be affected by low consumption fixtures, however, a reduction in wet vent pipe sizing may be permitted with the use of low consumption fixtures.

Hydraulic Load (Article 6.3.2)

Low consumption fixtures will not generally impact the minimum size of supply pipe to the fixture. The hydraulic load on the supply system, however, will have to be adjusted in Table 6.3.A to reflect low consumption fixture demand, or a supplementary calculation will have to be developed to arrive at the actual load for a listed low consumption fixture.

4.4
Impacts of Low-Consumption fixtures on Municipal and Private Sewage Systems

In general, low consumption fixtures exert a positive impact on municipal and private sewage systems. Two major benefits attributed to low consumption fixtures on sewage system performance deal with an extension of the useful life of the infrastructure and a reduction in basement flooding potential.

Municipal sewage treatment plants are known to function more efficiently when the effluent is less diluted, as the rate of treatment is accelerated with increased concentration of the effluent. Treatment plant operating costs are also directly proportional to the volume of effluent to be treated, such that even greater economy is possible by reducing effluent volumes while improving the biochemical oxygen demand (BOD) rate of sewage. Water conserving technologies, in addition to providing lower operating costs, can extend the life of treatment facilities thereby positively influencing their lifecycle utility.

Past experience with low consumption water closets indicates that reductions in sanitary sewer flows of approximately 9 percent are attainable in residential developments. This presumably translates into the potential for additional development or densification along the sewage system at a level corresponding to the reduction in sewer flow. It can also translate into deferring the need to expand costly sewer and water infrastructure, while meeting the requirements of expected new growth and development. This extension of the utility of the existing infrastructure results in significant economic benefit and may prove to be of further significance economically given that increased population density in urban centres also impacts the economic viability of social and transportation facilities.

Private sewage systems and non-municipally serviced developments are also positively impacted by low consumption fixtures. Presently in Middlesex County near London, Ontario, development has been frozen due to the volume of effluent entering the aquifer system from private sewage systems. Again, low consumption fixtures may extend the limits of development in these affected areas and permit development in marginal regions.

Low consumption fixtures have also been utilized in a golf course near Cornwall. Such fixtures contributed to a smaller septic bed system which otherwise would have been impossible. Low consumption fixtures will also lessen impacts associated with the contamination of ground water from overloaded septic systems.

Basement flooding resulting from inflow and infiltration to sewer systems by storm water during severe storms is a common problem in many municipalities across Canada. This problem has been extensively documented in two reports listed in the references to this section. According to these expert sources, reductions in sewer effluent may significantly increase the return period for basement flooding in affected areas. The high expense of damages associated with basement flooding appears to warrant low consumption sanitary fixtures as providing a cost effective flood prevention measure.

Sewage transport in municipal systems is not generally impaired by low consumption fixtures, however, some municipalities have expressed concern with their installation. In the case of the LeBreton Flats Water and Energy Conservation Demonstration Project in Ottawa, the municipal engineering department expressed concerns that low hydraulic loads would lead to clogging of the sanitary sewers. This concern has not been confirmed in North American practice and it is likely that municipal engineering departments underestimate the contribution of non-toilet sanitary sewer inflow, and infiltration, to sewage transport.

Two U.S. examples illustrate the negligible impacts of low hydraulic loads on sewer transport dynamics. In Phoenix, Arizona, preliminary assessments involving a demonstration between two similar subdivisions have indicated that new subdivision development should be able to cut average monthly water use by about 23%, simply by requiring all new development to incorporate 3 litre flush toilets, compared to similar existing developments which incorporate 13 litre flush models.

Although testing and monitoring were conducted over a relative short duration, the Phoenix demonstration showed an equivalent reduction in wastewater flows, which suggests beneficial implications for hydraulically overloaded sewage collection and treatment facilities. These impressive savings were also achieved with no detectable impacts on sewer transport or sewage treatment plant operation.

It has been demonstrated elsewhere that toilets in the 13-to-20 litre per flush range will not move effluent from the bowl to the sewer main in one flush. Instead, there is a reliance on wastewater from successive flushes and other wastewater from within the home to ensure the proper transport of waste flows. This is not surprising when one realizes that peak residential wastewater flows are primarily derived from non-toilet water use.

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4.5
Plumbing Code Issues

Some jurisdictions within Canada do not presently reference CSA standards for sanitary fixtures within their local Code requirements (for example, Ontario only requires that the toilet ballcock valve meet CSA requirements). While this may be interpreted to lessen the need to develop appropriate CSA testing procedures for low consumption fixtures, actual enforcement practices point to the opposite conclusion.

Municipal enforcement officials bear the liability for their decisions and look to performance associated with CSA certification requirements irrespective of provincial Code requirements. The same attitude tends to hold true for designers who specify equipment in buildings. As manufacturers' data may often be viewed as suspect compared to those obtained from testing laboratories, designers also require reliable fixture consumption data resulting from certification testing.

To reinforce, administratively, the attitudes of enforcement officials and designers in practice, the need for CSA certification of low consumption fixtures is seen as being necessary.

4.6
Guidelines and Possible Revisions to the Canadian Plumbing Code

On March 4, 1991, a meeting, led by the consultants on this study, was held to discuss U.S. experiences with low-volume plumbing fixtures and recent regulatory actions to mandate their use. (A list of attendees at this meeting appears at the end of this section.) Based on the findings from that meeting as well as Brown and Caldwell's experience in this area,[1] some general guidelines have been developed to help assist similar efforts in Canada. These include:

1. **Fixture Water Use Standards**. The recommended maximum flow rates for plumbing fixtures are as follows:

Fixture	Maximum Water Use
Toilet	6.0 lpf
Showerhead	9.5 lpm
Kitchen faucet (and replacement aerator)	9.5 lpm
Lavatory faucet (and replacement aerator)	7.6 lpm
Urinal	3.8 lpf
Clotheswasher	in development
Dishwasher	in development

2. **Fixture Marking and Labelling**. All plumbing products and fixtures, as well as the packages they are sold in, should be clearly labelled with information about the amount of water they use to guide consumers about their water usage and related costs. All fixtures should have indelible markings with this information, as some low-volume showerheads already do. It is recommend that the packaging labels contain information about the water use and costs associated with the product, and in comparison to higher and lesser volume products of the same type. Such a label could be modeler after the U.S. "Energy Use Guide" label that is required by federal law to be affixed to certain appliances such as refrigerators and clotheswashers.

3. **Product Performance Tests**. There is a need for revised uniform plumbing fixture performance standards to reflect real-world operating conditions that the current American National Standards Institute's (ANSI) Committee A112 Panel 19 standards do not now address. For example, as plumbing fixture retrofit programs continue to expand, a spate of devices to alter the flow rates of existing high-volume fixtures are now available. This equipment includes flushometer diaphragms, specialized faucet aerators, flushing devices for reduced water use, modified flapper valves, washers, and other flow-restriction devices.

Currently, a variety of these adapters is available with manufacturer claims that they reduce the flow rates of existing fixtures. However, no performance or materials standards exist for these products and thus manufacturers' claims about their merits cannot be easily evaluated and verified by recognized standards. Thus, it is presently difficult to determine the acceptable performance and value of such devices for inclusion in fixture retrofit programs. Until there are approved materials and performance testing protocols for these devices, backed up by independent, third party performance testing (e.g., by CSA, ULC, or ANSI), some discretion on the scale of application of retrofit devices seems warranted.

4. **Materials Standards.** Material standards for the operating parts of toilets are needed to reduce water waste from toilet leakage. For example, flapper valves typically begin to degrade and cause leakage within the first three years of toilet operation. Similarly, such standards are needed for other toilet fixture components and adapters, such as plastic dams and flushing devices used in retrofit programs.

5. **Product Tampering Prohibitions**. Some toilets and showerheads can be easily adjusted to use more water than their original design or law permits. Strict maximum water-use requirements for fixture hydraulic designs and anti-tampering language is needed in codes to ensure that plumbing products will not operate below their water-efficiency ratings.

6. **Revise Fixture Unit Values (FUV).** As new low-volume fixtures become installed, the pipe sizing for new houses and buildings can be downsized to accommodate reduced water use and flow rates. Thus, existing fixture unit valves should be revised to more efficiently size pipes for new building construction that will utilize low-volume fixtures. Research to revise FUV needs for new buildings has not yet been initiated in the U.S., due in part to the fact that new and existing buildings have been shown to easily accommodate reduced flow rates after the installation of low-volume fixtures.

7. **Enforcement**. Laws and codes mandating low-volume fixtures in the U.S. have been more effectively enforced when they include a strong enforcement component, such as the prohibition of sale of non-conforming fixtures. One loophole in the 1988 amendment to the Massachusetts Plumbing Code requiring 6 lpf toilets is that the code can only regulate what plumbers install, but not what is sold. Since there are not enough plumbing and building inspectors to check every toilet that is installed (and high-volume toilets are not marked with their water use rate), it is next to impossible to ensure that the code is being adequately followed and enforced. Since many plumbing product distributors openly and legally sell both low- and high-volume fixtures, it is not clear what level of code compliance exists. Thus, of the states that have passed low-volume fixture legislation and that also prohibit the sale of non-conforming fixtures, it is expected that they will have a higher compliance rate.

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4.7
Conclusions and Recommendations

There appears to have emerged a genuine need for basic research into the economic impacts associated with water conservation, (i.e., development cost, building costs, utility and infrastructure life, etc.) A fuller understanding of this relationship will permit a more appropriate approach to the funding of research, development, demonstration and implementation.

Harmonization of Canadian-U.S. standards is needed to cost effectively deliver water conserving technologies to the marketplace. Due to the vested interest of established manufacturers and the limited resources within CSA for standards research and development, it is likely that proponents of water conservation will have to provide significant funding to CSA to accelerate the development of meaningful, harmonized standards which result in the affordable testing of available technologies.

Canadian Plumbing Code changes to reflect low consumption fixture hydraulic loads and venting requirements are minimal but necessary to allow designers to gain the full economic benefit associated with low consumption fixtures. This may also provide an opportunity to rationalize many aspects of the plumbing code which represent inherited empirical prescriptive requirements which may be out of date, rather than technically supported performance requirements.

Communications initiatives aimed at educating municipal engineering departments expressing concerns relating to low-consumption fixtures will be required to adequately reduce barriers to water conservation measures, as well as to explain the far reaching benefits associated with water conservation.

Discussions with enforcement authorities and designers continue to represent a path which parallels communications with municipal engineering departments. Past experience indicates that both Code and CSA requirements are not uniformly or correctly applied and this may impair Canadian development of appropriate water conserving technology.

Finally, consumer awareness and education is needed to drive water efficient technology in the marketplace.

5.0
Discussion

5.1
Implications of Water Conservation on Infrastructure Requirements

Throughout this report significant benefits associated with reductions in water consumption in the residential sector are identified. Benefits include the reduced demand for potable water supply, reduced stresses on aquatic environments, and reduced wastewater flows. Increasingly, in an era of growing fiscal constraints, municipal and provincial water authorities are looking to various water conservation programs and initiatives as one way to defer costly infrastructure expansion plans, including wastewater treatment.

Implicit in this discussion is an identification of the types of programs and conservation efforts which can be expected to have a predictable, *sustainable* impact on water consumption and wastewater flows. A certain level of confidence about the sustainability of the impact of the conservation program or measure is the necessary precursor to making longer-term infrastructure planning decisions, as well as accommodating any needed repairs, upgrades, and allowing for growth.

In the case of fixture *replacement* programs — involving, for example, the installation of low volume toilets and showerheads — and in the case of new development incorporating mandated water efficient technology, structural change is built-in to the system. As a result, a high level of certainty is available to water planners about future infrastructure planning and capacity requirements. Such demand management programs can be regarded as providing the best guarantee of sustainable demand *reduction*.

Other programs, such as bans on lawn watering and car washing at certain times of the day, benefit the water utility more in terms of their impacts on managing the utility's peak requirements. Similar to time of use rates adopted by numerous electric utilities, these demand management programs simply shift the load or demand to an off-peak period. There may be no real demand reduction — in fact, rates of use may stay the same or may increase.

In the case of fixture *retrofit* programs — involving, for example, the retention of existing toilets and showerheads but modifying them in some manner to reduce their rate of water use per cycle — water savings can be immediate and significant. However, performance data on these devices has only been collected for the past three to five years, and the data that does exist is largely anecdotal. As such, water conservation specialists, although impressed with the preliminary performance information on these devices, are cautious about the longer-term impacts of fixture retrofit programs.

For example, toilet dams used in the early to mid-eighties in several retrofit programs in the U.S. failed after six months of use. Although there have been improvements in the quality of materials used in the manufacture of toilet dams, several water conservation researchers are predicting a 50 percent failure in these devices after five years in use (Babcock, Corpening, pers. com., 1991).

Concerns have also been raised by several authorities in the field of conservation retrofits (Babcock, Corpening, ibid.) about the design of several toilet retrofit devices. Alternative flush devices (AFDs) are becoming popular as water conserving devices in many toilet retrofit programs. Two of the more popular types, generically referred to as dual-flush and early-closure devices, take advantage of the potential energy and pressure head in a standard 20 litre, gravity flush toilet tank, but close the flush valve or flapper after the tank is only partially evacuated. In theory, this interruption in the flush cycle occurs after siphonic action has been created in the bowl.

Initial performance reports on these devices indicate that they are effective in reducing water consumption, however, their performance is dependent on the toilet design in which they are installed. Some concern has been expressed by water conservation researchers about the impacts of these early closure devices on the basic hydraulic performance of the toilet.

The issue involves striking a balance between the need to reduce water consumption, and the need to ensure a minimum level of sanitary performance for the health and safety of the user. As one researcher has described the dilemma: "if you cheat the flush, you may not have enough water coming back into the tank to restore the trap seal." Compromising the trap seal may lead to the back-drafting of sewer gases into the living area.

In addition to concerns about the quality of materials used in the manufacture of these retrofit devices, and their design, there is an additional problem associated with the rates of retention and removal of water dams and displacement devices by home occupants. Retention rates in an owner-occupied demonstration in Marin County, California showed a reduction in use by over 25 percent after a five year period.

Retention rates in rental situations involving tenants have not been documented. However, to the extent that tenants usually have little incentive to save water in cases where the benefits accrue only to the landlord or building owner, there is a distinct possibility of tampering with and removal of the devices.

And yet, despite a paucity of data on the rates of retention — and long-term performance — of commonly used retrofit devices, the U.S. case studies documented in Section 2.4 indicate that one of the primary objectives of plumbing fixture retrofit programs is to avoid or delay capital expansion costs for new facilities.

In the case of the San Jose program, the primary motivation was to reduce wastewater flows and postpone the need for an expansion to a sewage treatment plant. In the cases of both Boston and Seattle, the programs were motivated, at least in part, by the need to avoid augmenting sources of supply.

One of the undeniable attributes of fixture retrofit programs is their ability to raise the awareness of water consumers about the importance of water conservation. The devices provide hands-on experience for the uninitiated consumer, and assist in bringing the technical and behavioral aspects of water use in the home into better focus. Behavioral scientists agree that this is a necessary precursor to modifying the water-using habits and behaviors of consumers.

An added benefit of retrofit programs is the immediate results they can generate, if properly designed, delivered and monitored. In the case of communities experiencing some sort of water emergency, retrofit programs can be instrumental in getting the water utility and the community "over the hump". However, the ability of various retrofit devices — particularly toilet adaptations — to sustain the savings over the long-term, has yet to be rigorously tested. The "failure" of these devices on a wide scale in five years time could have political implications if the decision-making was based primarily on a perceived infrastructure benefit.

The problem extends beyond the limited data from the field on performance, retention rates and degradation characteristics for these devices. Very few of these products have undergone independent, third party testing, nor have ANSI, ASPE or CSA developed any testing protocols covering the performance of these devices and their component materials. In response to this situation, the Metropolitan Water District of Southern California is funding a US$50,000 research project at the Stevens Institute of Technology in New Jersey to determine long-term performance of these devices.

Therefore, the assumption that all retrofit devices result in lasting water reductions should be viewed with caution. Leading experts in the field, both in the US and in Canada, share divergent opinions on the subject. Until the required performance and materials testing have been completed on the wide range of water conserving retrofit devices — especially the ones designed for toilets — several researchers are recommending that they should not be looked upon as a method of permanent demand reduction (Babcock, Corpening, Macy, pers. com., 1991).

5.2
Consumer Marketing Strategy

Encouraging the public to conserve water can be largely achieved by developing and implementing a broad program of social marketing. The program will consist of a plan to inform, motivate and lead the public to sustained change in attitudes and behaviour towards water use.

Research in the area of social marketing programs has found that a broad change in societal attitudes and behaviour can be accomplished through a well crafted program which includes interpersonal interventions and incentives, and directed media appeals.

Preceding sections of this report have described a variety of methods to decrease water consumption. This section outlines the basic terms of reference for a strategic plan to change public attitudes and behaviours towards water use.

The process of developing a strategic plan involves six interrelated activities, in large, carried out at the municipal level:

- Stating clearly the objectives of the program;
- Identifying both the target groups (called Target Adopters) which would become the focus of the marketing strategy and groups who might become partners in promoting and implementing aspects of the plan;
- Conducting baseline marketing research to understand the values, attitudes and behaviours of the target audiences;
- Developing the "messages" and actual programs for effecting long term behavioral changes in the public's use of water;
- Choosing the vehicles or interventions with which to change attitudes and behaviour toward water conservation; and
- Obtaining, at frequent intervals, feedback and other evaluative information to be used in refining the plan and adoption of follow-up actions to ensure its ongoing success.

5.2.1
Objectives

The overall objectives of this marketing plan, at the municipal level, are to:

- Promote awareness of the issues involved in water conservation;
- Educate the public on the necessity of and the means to achieve water conservation; and
- Encourage long-term change in water use.

Existing research on environmental concerns suggests that the environment for many individuals is a personal concern. Individuals are interested in what they can do to help. Accordingly, to accomplish water conservation objectives, a program which speaks to the individual regarding his/her efforts to change behaviour and attitudes is required.

Appealing to the individual through an integrated program matches the current perception on the part of the public that it is time for individuals to take responsibility and make changes. Thus a program with concepts similar to a recent waste management campaign in the Greater Toronto Area would be a good approach.

This campaign has had similar objectives to a water conservation program. A range of mass media advertising and information spots have been used to sensitize the public to the three R's of waste management and provide education and tips on what individuals can and should be doing to reduce and to identify a specific reduction target (e.g. 10 per cent over a certain number of years).

5.2.2 Target Adopters

While the general public in any one municipality is the major target of this social marketing campaign, it would be advisable to identify smaller target groups. While the overall message may be the same, or similar, a variety of interventions can be tailored for the specific Target Adopter. Suggested groups include:

- Home Owners - Current and New
  - targeting home owners on the basis of indoor and outdoor water usage or single family households vs. multiple residential units.

- Elementary School Children
  - in-school educational programs should be subdivided by grade level (e.g., primary grades 1 to 3, and junior grades 4 to 6).

- Residential and Commercial Real Estate Developers, Condominium Corporations, Large Landlords and Property Management Companies.

- Industry/Business using water in their processes
  - subdivide by process, especially when targeting those using water for process cooling and other consumptive uses.

- General Public

Suggested interventions are discussed below.

Partners in Water Conservation

Other levels of government and provincial and municipal utilities are obvious partners with which to create a co-ordinated effort and to jointly sponsor a media campaign and conservation program. It seems likely that a greater effect will be attained if several levels of government and associated agencies are perceived to be supporting and/or funding the efforts. (The credibility and value of this type of endorsement can be probed in the market research.)

Agencies such as Provincial electrical utilities are potential partners to be considered. In recent months Ontario Hydro has launched campaigns to reduce electricity use. At least two of their programs - water heater tune-up, and showerhead and faucet aerator programs - directly encourage consumers to use water more efficiently as a means of reducing electrical consumption. B.C. Hydro has similar programs in place. In these types of programs there is potential for government at several levels to share sponsorship of the program, the costs associated with incentives and the advertising.

Similarly, incentive programs can be created where sponsorship is shared with kitchen and bathroom fixture dealers who sell water efficient toilets and showerheads. In these types of programs dealers might share in the cost of advertising but would be the front line for sales of water efficient products to customers, who receive a rebate for buying the product.

5.2.3
Baseline Market Research

In order to create a well targeted water conservation campaign, market research is essential to obtain information on the socio-demographic characteristics, attitudes, values and motivations, and behavioral patterns of Target Adopters.

For water conservation the following topic areas should be included in the survey:

- Attitudes towards conservation and the environment;
- Understanding of and concern for water conservation;
- Current water use patterns and conservation behaviours, and related motivating factors for conservation in general;
- Acceptance of and resistance to various conservation options including installation of meters, higher rate structures and water saving devices and fixtures;
- The credibility of a variety of governmental and non-governmental groups on the issues of water conservation; with the intention of discovering the most credible source to speak on the issue;

- Media consumption, preferred information vehicles and interest in interpersonal interventions.

A draft questionnaire is included in Appendix B

5.2.4 Message Definition

Given recent concern about environmental and waste management issues, objectives readily emerge for the issue of water conservation. Crafting the context of the message to Target Adopters, however, is a more complex task. For example, under the federal government's Green Plan, and the Environmental Citizenship (Education) initiative in particular, water will be a major issue, incorporating a 3 to 6 year education campaign. It will be important for all levels of government to adopt similar messages to ensure that the public perceives that the water conservation message is being reinforced, not duplicated.

Examples of the basic messages to be conveyed by the program are:

- water conservation is "important to everyone", or "environmental citizenship" requires environmental responsibilities on the part of everyone;
- more water is being used than is necessary; and
- using less water is good for everyone and will benefit the Target Adopter in particular.

The way these themes are presented to the public (i.e. the spin that is put on them) must be carefully defined such that the Target Adopters receiving the message are motivated to become informed about the issue, to consequently act in a conserving manner, and sustain their actions over the long term.

In this sense, the messages which will form the backbone of the water conservation campaign are similar to other products being sold. The message must fit the target group's perceptions, attitudes and motivations. According to research on successful social marketing, the wrong fit can result in an inadequate or contrary response by Target Adopters.

Attaining an understanding of how to fit the message to the target adopter group is achieved through baseline research in which the attitudes and behaviours of the target group are probed. A detailed understanding the target adopter's orientation to water conservation and personal motivation towards conservation will suggest the most acceptable message and the factors more likely to motivate Target Adopters to conserve water.

Once messages have been created, these too should be tested with individuals who match target group characteristics. This will allow fine tuning of the messages prior to their launch.

5.2.5
Interventions — Interpersonal and Direct

A wide variety of interventions exist for educating the public about water conservation and encouraging changes in behaviour. Many have been discussed in preceding sections. A well developed program should match interventions to the attitudes and motivations of the specific Target Adopters probed in the baseline research. This section outlines suggested interventions and incentive programs which could be developed for each of the target groups.

As mentioned previously, much of the literature which has assessed past programs for social change shows that successful programs use both media campaigns and interpersonal interventions. Discussed below are suggestions for the programs which could be developed.

Home Owners — Current

a. **Water conservation audit or tune-up.** This type of interpersonal intervention takes the form of an audit of the home owner's potential for saving water. It is an effective way of educating the public, distributing inexpensive water conservation kits (including such products as toilet dams, faucet aerators and showerheads), motivating consumers to change their behaviour, and promoting other water conserving products (e.g., water efficient toilets) and techniques (e.g., better watering habits).

Many ways exist for launching this type of program such as advertising the program to selected communities or sending letters through local utilities. The audit can be performed through direct personal contact (personal interview) or indirect contact by means of a questionnaire and follow-up report mailed to the respondent.

This type of audit can be as small or large in scale as resources permit. It can be completed systematically in small to medium sized communities. The key is to avoid raising expectations which cannot be met. All who respond to the program must be contacted and the audit conducted. Co-ordination and personnel resources are critical.

General Public

a. **Conservation kits of products for reducing water use.** These kits can be distributed in a number of ways, as described in the U.S. case studies in Section 2.4, or to the general public, in schools or shopping malls and home shows. They would include brochures and other information pieces with practical tips for water conservation.

b. **Rebate coupons.** Incentives in the form of rebate coupons for having purchased more expensive items such as water efficient toilets and showerheads are straightforward programs to develop. They influence people to use water saving devices before they might have done so on their own.

Purchasers sending for the rebate, receive educational materials and other coupons. The names could become part of a general database for further correspondence.

c. As outlined above in the partnerships section. To encourage purchasing water efficient toilets, faucets and showerheads, a possible way to influence the adoption of water conservation among new home buyers is to develop a program of incentives in which rebates are paid to the home buyer and the developer who makes the products part of the development. Other incentives include awards and public recognition for those who live in water efficient homes.

School Children

a. **Children's educational kits**. As discussed above, educating children about water conservation is an important long term strategy.

b. **National curriculum**. Besides information kits and products to be taken home, a national curriculum could be developed with educators to instill water conservation values.

c. **Tours** of water purification and sewage plants to develop a sensitivity to water use and requisite filtration/treatment processes would reinforce the school curriculum.

d. **Speakers bureau**. Water supply authorities speak to classes.

e. **Community project**. Hands-on retrofit of an identifiable section of the city for purposes of monitoring.

Local Municipalities and Water/Hydro Utilities

a. Develop a program of incentives to encourage Municipalities to change rate structures.

b. Water saving messages to accompany utility bills.

Business/Industry

a. Develop an information program which educates Businesses and Industries which use water in their processes about the need to conserve water.

b. Develop a program of incentives to encourage Industry to change processes or to find ways to use less water.

c. Dovetail with existing trade shows for visibility within the community.

Media Vehicles for the Campaign

Bill Inserts - Local Municipalities and Water/Hydro Utilities

Utility bills (both water and hydro) are excellent places to include promotional messages to alert consumers to the water conservation ethic and advise on incentive (rebate) programs for which they are eligible. The federal government is currently working with the Region of Ottawa/Carleton in a partnership to develop some of these ideas further.

Brochures and Posters

Brochures and posters represent opportunities to inform and educate in a indirect manner. Brochures and posters should be created for each sub-program of the overall water conservation campaign. The messages should be targeted to the group to which the information is aimed.

More specifically, however, information pieces should be created which are eye catching and serve as quick reference guides containing practical tips for water conservation.

Multi-Media Advertisements

Transit ads, radio spots, mass circulation magazine articles, and special features on news and information talk shows are the tools of a mass media appeal to raise awareness of the issue and to educate the public on what they can do. Again, the intention would be to provide quick tips of practical information on what the individual can do to conserve water.

5.2.6
Process Evaluation of the Water Conservation Program

It is important to build into all pieces of the program - media campaigns, pamphlets, incentives and interpersonal interventions and audits - formal devices to monitor and evaluate the impact of both the messages and interventions.

Evaluations should be completed at least three times during the program: at the program planning stage, at mid-program and after the program ends.

Where baseline research aids in planning the program, the information obtained at mid-program can be used for fine tuning of the specific program piece (i.e. advertising or incentive for purchasing a water conservation product) for ensured success.

Evaluations at the end of the program allow for assessing the success of the program as well as for completing cost/benefit analyses.

Appendix A
Water Conservation Strategy

How To Use This Chart

Appendix A contains a series of charts which provide, on a room by room basis, a water conservation strategy for a residential situation. As such, the charts provide a quick reference guide to the devices and appliances that go to making a water conserving household.[1]

The charts themselves are relatively self explanatory. In each case:

- a water-using device or appliance is described, with a particular emphasis on its place in terms of overall household use;
- a variety of technological options are described in terms of the efficiency of their use of water;
- a recommendation of a particular option is given; and
- an estimate of water savings to be expected.

In all but a few cases, mid-efficiency technologies have been recommended. The reasons for this are two-fold. Firstly, to show how much water can be conserved by a relatively simple 'hardware' adjustment. Secondly, in some cases, as with toilets, consumers may not yet be ready to accept appliances and devices that require such small amounts of water.

Obviously, the more water-efficient devices and appliances installed, the greater the water savings. But, it is by no means necessary to implement all of the recommendations. In each room, or area of the house, devices have been listed beginning with those that use the most water, and ending with those that use the least. Concentrating available capital resources on the largest water users will also result in significant savings in water costs.

One final note of clarification: the final column in each technology category provides an estimate — where a reliable estimate is available — on water savings over the course of a year. In each case, these are based on the assumption that the device has been installed in a residence, and used by a family of four. For the most part, those figures were drawn from the Environment Canada publication, *Water: No Time To Waste*.

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[1] The devices and appliances listed in the chart are more fully described in terms of performance and application in Section 3 of this report.

Technology	Bathroom				
Toilets	**Litres Per Flush**			**Recommendations**	**Potential Savings**
	Conventional	Mid-Effic.	High-Effic.		Per Flush / Per Year
Toilets are the largest water user in the home. It is essential that they be considered a prime target in creating water-efficient housing.	Conventional toilets use between 14 and 23 litres per flush, with 20 litres representing the 'norm'.	Manufacturers now make a toilet that flushes using only 11 litres.	There is toilet technology available that requires six litres or less per flush	Recommend a mid-efficiency toilet as being more palatable to consumers at this point in time. Ensure that all water efficient toilets have met CSA standard B45.	Potential savings with a mid-efficiency toilet of 9 litres per flush. / Assume a family of four and six flushes each per day: that would result in an annual savings of 65,500 litres.
Showers	**Litres Per Minute**			**Recommendations**	**Potential Savings**
	Conventional	Flow Restrictors	Water-Effic.		Per Year
Next to toilets, showers and baths are the largest drain on household water use. While little can be done – in a technological fashion – about bath water use, plenty can be done about shower water usage.	Conventional showerheads have flow rates up to 20 litres per minute.	Flow-restrictors – a washer with a hole in it – reduce flow through the showerhead. Variable performance rating. Not popular with consumers.	Low-flow showerheads which have flow rates between 6 to 10 litres per minute are widely available. Similar amenity values to conventional fixtures.	Recommend a low-flow showerhead – both aerated and non-aerated have been found to perform satisfactorily. If possible, install low-flow showerheads which have a built-in shut-off button.	If a family of four each takes a five minute shower every day, they will use 3,000 litres of water each week – or 156,000 litres of water each year. A low-flow showerhead that reduces the flow rate by fifty per cent can potentially save 78,000 litres of water annually.
Faucets	**Litres Per Minute**			**Recommendations**	**Potential Savings**
	Conventional	Mid-Effic.	High-Effic.		Per Minute / Per Year
Conventional bathroom faucets deliver much more water than, in most cases, is needed or can be used.	Average flow rates of 13.5 litres of water per minute.	Aerators which reduce flow rates of 6 to 9 litres per minute.	Aerators which reduce flow rates to around 2 litres per minute.	In the bathroom, aerators which reduce the flow to 2 litres per minute are recommended.	A high-efficiency aerator will reduce water use by 11.5 litres per minute. / N/A
Application of mid-efficiency technologies could reduce water use in the bathroom by forty per cent or more.					

Room By Room Water Conservation Strategy – The Kitchen

Technology	Kitchen					
Faucets	**Litres Per Minute**			**Recommendations**	**Potential Savings**	
	Conventional	Mid-Effic.	High-Effic.		Per Minute	Per Year
Drinking and cooking accounts for only about 5 per cent of household water use. Still, the installation of faucet aerators in the kitchen can translate into significant water savings.	Average flow rates of 13.5 litres of water per minute.	Aerators which reduce flow rates of 6 to 9 litres per minute.	Aerators which reduce flow rates to around 2 litres per minute.	In the kitchen, aerators which reduce the flow to 6 to 9 litres per minute are recommended. While kitchen use is low, significant flows are required, especially where dishwater hook-ups are necessary.	A mid-efficiency aerator can reduce water use in the kitchen by about 25 per cent.	For a family of four, a kitchen aerator can translate into annual water savings of 6,387 litres.
Dishwashers	**Litres per Cycle**			**Recommendations**	**Potential Savings**	
	Conventional	Water-Efficient			Per Cycle	Per Year
	Conventional dishwashers can use a significant amount of water – up to 1,200 litres per month.	At present, few water efficient dishwashers are readily available. In general, European appliances tend to be more water-efficient than their North American counterparts.		Look for dishwashers that allow different load settings. Dishwashers can also be large users of electricity. Look for appliances with low Energuide Ratings.	N/A	N/A Using a dishwasher only when it is full to capacity could result in a savings of several operating cycles each week.
Water Treatment Systems and Automatic Garbage Disposals	**Litres Per Cycle**			**Recommendations**	**Potential Savings**	
	Water-use by water treatment systems vary from system to system. Expect a mid-size system to use approximately 10 000 litres per month for flushing and regeneration. Water-use by automatic garbage disposals is dependant on use patterns by residents.			In general, home water treatment systems and garburators are not recommended, due to excessive water-use requirements.	N/A	
Application of mid-efficiency technologies could reduce water use in the kitchen of at least ten per cent.						

Room By Room Water Conservation Strategy – The Laundry - Utility Room

Technology	Laundry - Utility Room			
Automatic Clothes washer	**Litres Per Cycle**		**Recommendations**	**Potential Savings**
	Conventional	Water-Efficient		Per Cycle / Per Year
In the laundry room, the automatic clothes washer is the main user of water. Automatic clothes washers and automatic dishwashers account for approximately 20 per cent of residential water consumption (indoors).	An automatic clothes washer can use from 150 to 250 litres of water for each cycle – for a family of four, that can amount to 1,200 litres of water over the course of each month.	At present, few automatic clothes washers are manufactured specifically to be water-saving. In general, European appliances tend to be more water-efficient. Front-loaders, where they can be found, use up to one-third less water.	Look for automatic washers that have a suds-saver, as well as variable load-settings. It is also recommended that appliances with low Energuide Ratings be given preference.	N/A / N/A Using a clothes washer only when it is full to capacity could result in saving several operating cycles each week.
Faucets	**Litres Per Minute**			**Recommendations**	**Potential Savings**
	Conventional	Mid-Effic.	High-Effic.		Per Flush / Per Year
	Average flow rates of 13.5 litres of water per minute.	Aerators which reduce flow rates of 6 to 9 litres per minute.	Aerators which reduce flow rates to around 2 litres per minute.	Faucet aerators are not recommended in the laundry or utility area because of the large volumes of water required over short periods of time.	N/A / N/A
Hot Water Tank	**Recommendations**				**Potential Savings**
Reducing stand-by heat losses reduces water use because hot water stays at the desired temperature longer.	A family of four may spend up to $600.00 per year to heat hot water. Insulating the tank and the hot water pipes will reduce stand-by heat loss, reducing water heating costs by as much as 25 per cent. Heat traps are also recommended as a measure to reduce heat loss.				N/A
N/A					

Appendix B
Water Conservation Questionnaire

Hello, my name is _____, I'm calling from *(Name of Research House)*. I would like to take a few moments of your time to answer some questions on current issues and events.

(Complete standard screen for selection of person within the household and for persons not working at market research firms.)

1. First, what does the word "conservation" mean to you?

_____

_____

_____

_____

2a. Do you think it is very important, somewhat important, not very important or not at all important that people practice conservation?

1-Very important
2-Somewhat important
3-Not very important
4-Not at all important

2b. Why important/Why not important?

_____

_____

_____

3. What, if anything, do you currently do to personally practice conservation? **(ACCEPT TWO ANSWERS)**

1-No, nothing

_____

_____

4a. What does the term "water conservation" mean to you? *(ACCEPT TWO ANSWERS)*

_____

_____

_____

_____

4b. Do the terms "water conservaton" and "using water efficiently" mean the same or something different to you?

1-Same
2-Different

5. What, if anything, do you do personally to conserve water? *(ANSWER MUST BE AT LEAST 10 WORDS. LIST AS MANY ACTIVITIES AS MENTIONED.)*

_____

_____

_____

_____

6. In your opinion, how likely is it that *(respondent's province)* will be facing water shortages within the next few years ... *(READ)*

1-Very likely
2-Somewhat likely
3-Not very likely
4-Not at all likely

7. When you do each of the following things, how often do you actually think about the fact that you are using water? The first is **READ ONE OPTION AT A TIME, FOLLOWED BY THE FIVE CHOICES.** Do you think about the fact you are using water all the time, most of the time, some of the time, very rarely or never?

a. Wash dishes

1-All the time
2-Most of the time
3-Some of the time
4-Very rarely
5-Never

b. Wash clothes
c. Water lawn
d. Wash the car
e. Shower or bathe
f. Brush teeth
g. Flush the toilet
h. Cook
i. Make coffee or tea

8. Thinking about your own household compared to others, do you think the amount of water your household uses is far above average, a little above average, average, a little below average or far below average?

1-Far above average
2-A little above average
3-Average
4-A little below average
5-Far below average

9a. If there were a need to cut back on the amount of water you use, do you think this would result in a major, minor or no change in your lifestyle?

1-Major change
2-Minor change
3-No change

9b. What changes or cutbacks would you make?

_____

_____

_____

_____

10. Some people believe it is so important we use water efficiently, we should make it mandatory that people use water efficiently, and if they don't they would pay some penalty. Would you strongly favour, somewhat favour, somewhat oppose or strongly oppose this idea?

    1-Strongly favour
    2-Somewhat favour
    3-Somewhat oppose
    4-Strongly oppose

11. Some people believe it is so important we use water efficiently we should reward those who use less water, thereby saving it. Would you strongly favour, somewhat favour, somewhat oppose, strongly oppose this idea?

    1-Strongly favour
    2-Somewhat favour
    3-Somewhat oppose
    4-Strongly oppose

12. Compared to other standard household expenses (electricity, taxes, food) would you say the price you pay for water is. . . **(READ)**

    1-Too high
    2-Too low
    3-Just right

13. Now I'm going to read you a list of statements various people have made at one time or another. Please tell me how you personally feel about each statement giving me a number between 1 and 10 were "1" means you totally disagree with the statement and "10" means you totally agree with the statement. Many people's opinions fall somewhere in between these two points depending on how they feel about the statement. The first statement is. . . *(REPEAT SCALE INSTRUCTION IF NECESSARY)* Where would you place yourself on this scale? *(READ AND ROTATE)*

    Totally Disagree **Totally Agree**

    1 2 3 4 5 6 7 8 9 10

a. When I see my neighbours using less water then I will join in.

b. We can preserve the quality of life — and the environment — in Canada for the future by using water more efficiently now.

c. The price I pay for water is pretty cheap given how much I use it.

d. I'm not willing to spend hundreds of dollars on water restricting devices and appliances to make my household use water efficiently.

e. The saying "Waste not, want not" applies to my thinking about how I use water.

f. It makes me feel good when I do things to use water more efficiently at home.

g. I would conserve more water if it didn't cause such inconvenience.

h. The price I pay for water is a household expense which I don't think much about.

i. I'd be making sacrifices in my lifestyle if I cut back on my consumption of water.

j. I personally have a responsibility to use water efficiently.

k. I would try to use less water if I knew it was helping the environment.

14. Now I'd like you to think about your use of water at home and place yourself on a scale of 1 to 10 where "1" means you do not at all think about its use and "10" means you think a lot about your water use.

Don't at all think about water use — Think a lot

1 2 3 4 5 6 7 8 9 10

15. From what you have heard or seen, what kind of job has each of the following currently been doing to promote using water more efficiently? *(READ AND ROTATE)*

a. The Federal Government

1-Excellent
2-Good
3-Fair
4-Poor

b. Environment Canada
c. Your Provincial Government
d. Your Municipal Government
e. Canada Mortgage and Housing Corporation

16. Who would you expect to offer programs to help you reduce the amount of water your household uses? *(READ AND ROTATE)*

1-The Federal Government
2-Your Provincial Government
3-Environment Canada
4-Your Municipal Government
5-Manufacturers of water conservation appliances

17. In your opinion, how credible are each of the following in speaking about and as sources of information for using water efficiently? *(READ AND ROTATE)*

a. The Federal Government

1-Very credible
2-Somewhat credible
3-Not very credible
4-Not at all credible

b. Environment Canada
c. Your Provincial Government
d. Your Municipal Government
e. Canada Mortgage and Housing Corporation

18a. How interested are you in learning how to conserve water and how to use water more efficiently?

1-Very interested
2-Somewhat interested
3-Not very interested
4-Not at all interested

18b. If you wanted information on how to use less water and generally use water more efficiently, where would you go to get this information? *(DO NOT READ LIST, ACCEPT TWO RESPONSES)*

1-Television
2-Newspapers
3-Other news media
4-Local municipality
5-Provincial government
6-Friends/relatives
7-Other (specify)

19. How effective would each of the following be in getting you to use less water? *(READ AND ROTATE)*

a. Information pamphlets describing what you can do to use less water.

1-Very effective
2-Somewhat effective
3-Not very effective
4-Not at all effective

b. Community meetings which discuss the quality and availability of water in your community and show how to use less water.

c. Radio or television commercials to remind you how to save water.

d. Reminder and information stickers for your bathroom, kitchen fridge and other appliances (dishwasher, washer).

e. Higher water rates.

f. Television or radio programs which explain how to use water more efficiently.

g. Information pamphlets and school programs for children.

20. Each of the following appliances and activities would help reduce the amount of water used in your household. How likely would you be to do any of them. The first is *(READ AND ROTATE LIST)*. . . Would you be very likely, somewhat likely, not very likely, not at all likely to do this?

a. Buy and use a water efficient showerhead.

1-Very likely
2-Somewhat likely
3-Not very likely
4-Not at all likely

Volunteered
5-Already do this or have it

b. Buy a water efficient toilet.

c. Use a faucet aerator to lessen amount of water used.

d. Turn on the dish washer only when it is full.

e. Water your lawn less frequently in hot weather.

f. Be careful not to let tap water run while brushing your teeth or while shaving.

g. Consciously use less water in cooking.

h. Use a soaker hose for garden and lawn watering rather than a sprinkler.

i. Take more showers than baths.

j. Use the shut-off button on your showerhead while soaping-up or shampooing your hair.

21. Would the following be very acceptable, somewhat acceptable, not very acceptable or not at all acceptable to you as a measure to use water more efficiently?

a. Filtering water that drains from bathroom basins, tubs and laundry rooms and then reusing this 'grey' water to water lawns and gardens or for toilet flushing.

1-Very acceptable
2-Somewhat acceptable
3-Not very acceptable
4-Not at all acceptable

22. How interested would you be in the following appliances to help your household use water more efficiently, if programs existed which helped to reduce the cost to you. The first is . . . *(READ AND ROTATE LIST)* Would you be very interested, somewhat interested, not very interested, or not at all interested in this?

a. A cash rebate on a water efficient showerhead.

1-Very interested
2-Somewhat interested
3-Not very interested
4-Not at all interested

b. A subsidy/cash rebate toward purchasing a water efficient toilet.

c. Free faucet aerators.

d. A subsidy to buy a water efficient dishwasher or clothes washer.

e. A free water heater blanket and pipe wrap to help keep water hotter longer.

23. Demographics

- age
- education
- occupation
- household income
- type of dwelling lived in
- type of water service, if any
- number of people in household, number of children at home
- readership of newspapers and magazines
- radio listening habits
- television viewing habits
- types of water-using appliances owned
- types of behaviour in household (i.e. how often shower and bath, loads of laundry per week, loads of dishes)

Appendix C
Additional Charts

Application	Water-Saving Device	Function	Water Savings	Estimated Unit Water Savings L/d per capita
Toilet	Low-flush toilet 13 litres per flush	Reduce flush volume	8 L/flush (2 gal/flush)	30.3 (8.0)
Toilet	Low-flush toilet 6 litres per flush	Reduce flush volume	15 L/flush (4 gal/flush)	60.6 (16.0)
Shower	Low-flow shower 10.4 litres per min.	Reduce shower-flow rate	5.7 L/min (1.5 gpm)	27.3 (7.2)
Faucet	Aerator	Reduce faucet-flow rate	—	1.9 (0.5)
Appliances	Water-efficient dishwasher	Reduce water requirement	19 L/load (5 gal/load)	3.8 (1.0)
Appliances	Water-efficient clotheswasher	Reduce water requirement	23 L/load (6 gal/load)	6.4 (1.7)
Hot-Water System	See text	Reduce hot water use	—	—

Chart: Water-Conserving Devices for New Construction *Source: Brown and Caldwell Consult. Engrs.*

Application	Water-Saving Device	Function	Water Savings	Estimated Unit Water Savings L/d per capita
Toilet	Toilet-tank displacement bottles	Reduce flush volume	1.9 L/flush (0.5 gal/flush)	7.6 (2.0)
Toilet	Water-closet dam	Reduce flush volume	3.8 L/flush (1 gal/flush)	15.1 (4.0)
Toilet	Toilet-tank bag	Reduce flush volume	2.6 L/flush (0.7 gal/flush)	10.6 (2.8)
Shower	Flow restrictor	Limit flow to 10.4 L/min	—	14.0 (3.7)
Shower	Low-flow shower head	Limit flow to 10.4 L/min	5.7 L/min (1.5 gpm)	27.3 (7.2)
Faucets	Aerator	Reduce faucet flow rate	—	1.9 (0.5)
Toilet leaks	Ballcocks flapper valves	Stop leaks	91 L/day/toilet (24 gal/day/toilet)	

Chart: Retrofit Devices for Existing Housing *Source: Brown and Caldwell Consult. Engrs.*

Location	Number of Kits	Per Cent Receiving Kit	Reason for Program	Date of Distribution	Devices Distributed
North Marin Water District, Calif.	1 300	100	Drought	1976 and 1977	Two 0.9 litre plastic bottles for toilet tank. One shower-flow restrictor One toilet-tank leak detection tablet
Phoenix, Ariz.	44 000	100	Sewer surcharging	June 1985	Two toilet tank dams Two low-flow showerheads
Austin, Texas	8 800	50	Wastewater treatment plant overflows	April 1984	Two toilet tank dams One low-flow showerhead Faucet aerators
San Jose, Calif.	13 000	100	Deferral of wastewater treatment plant expansion	1986	Two toilet tank dams Two low-flow showerheads Two toilet tank leak detection tablets
Aurora, Colo.	13 000	35	Save water	May 1984	One toilet tank dam Two showerflow restrictors Two toilet tank leak detection tablets

Chart: Door-to-Door and Depot Retrofit Programs

Location	Method of Distribution	Promotion Campaign	Cost in $	Installation Rate	Water Savings L/day/capita
North Marin Water District, Calif.	Door-to-door in response to direct-mail offer by volunteer service organizations	Direct mailing of notice/offer	31 000	Toilet tank bottles 60% Shower flow restrictors 30% Leak detection tablet NA	15.1 (40 gal/day/capita)
Phoenix, Ariz.	Door-to-door with follow-up free installation	Television public service announcements, press releases, media coverage, letter from mayor, billboards, installation instructions on cable TV	521 000	93% overall	11.2 (42.5 gal/day/capita)
Austin, Texas	Depot (by city)	Extensive media publicity about wastewater problems and kit availability	Not Available	Toilet tank bottles 86% Low-flow showerheads 75% Faucet aerator 82%	11.4 (43.1 gal/day/capita)
San Jose, Calif.	Door-to-door with follow-up canvassing and installation	Letter with water bill, mailing of flyer, and door-to-door	180 000	89% overall	11.2 (42.5 gal/day/capita) *estimate only*
Aurora, Colo.	Depot and door-to-door in response to direct-mail offer by volunteer organizations	Water bill insert, letters to groups, TV and radio public service announcements, newspaper articles, city council resolution	16 000	Toilet tank dams 53% Leak detection tablets 60%	6% of indoor water use

Location	Number of Kits	Reason for Program	Date of Distribution	Devices Distributed	Cost	Installation Rate	Water Savings
Los Angeles, Calif.	1,260,000	Save Water	June, July, 1981	One 2.6 L toilet tank bag Two showerflow restrictors Two toilet tank leakage tablets Water conserv. literature	$871,000	Toilet tank bags - 19% Showerflow restrictors - 10%	25.4 L/d per capita
San Jose, Calif.	475,000	Save Water and wastewater	May 1981	Two 2.6 L toilet tank bags Two showerflow restrictors Two toilet tank leakage tablets Water conserv. literature	NA	Toilet tank bags - 35% Showerflow restrictors - 17%	NA
Spring Valley Water Co., N.Y.	68,000	Save Water	June, July 1981	Two 2.6 L toilet tank bags Two showerflow restrictors Two toilet tank leakage tablets Water conserv. literature	$69,000	Toilet tank bags - 35% Showerflow restrictors - 19%	63.6 L/d per capita

Chart: Bulk Mailing Retrofit Programs

Location	Number of Houses	Reason for Program	Date of Distribution	Devices Distributed	Cost	Installation Rate	Water Savings
East Bay Municipal Utility District, Calif.	165	Pilot program	Oct., 1982	Toilet tank displacement bag; lowflow showerhead, faucet aerators; water conserv. literature	$11,000 for materials and labour	NA	21.6 L/d per capita
Orlando, Fla.	33,000	Wastewater treatment plant overflows	1983	Toilet tank dams; low-flow showerheads; faucet aerators	$134,000 for materials only	Approx. 70%	NA
Oak Park, Calif.	667	Drought	June, 1977	Toilet tank dams; shower flow restrictors	NA	Toilet tank dams - 89% (22% after 22 months) Showerflow restrictors - 76%	68 (wastewater flow)
Santa, Monica Calif.	5,500	Energy conservation	1984	Three of: low flow showerhead; faucet aerator; water-heater jacket; hot-water pipe insulation; weatherstripping	Approx. $80 per house	NA	NA

Chart: Direct-Installation Retrofit Programs

Appendix D
Annotated Bibliography of Selected Readings

Municipal Water Rates in Canada — 1986
Current Practices and Prices

Inland Waters Directorate, Social Science Series No. 21

An analysis of municipal water rates charged to residential and commercial consumers across Canada. Four hundred and seventy municipalities were reviewed and over 1100 different rate schedules were found. The four main types of rate schedules were: flat rate, constant unit rate, declining block rate, and increasing block rate. Most importantly, more than 70 per cent of the rate schedules in current use do not encourage efficient water use (e.g. flat rates, declining block rates). The analysis concludes with a discussion of criteria for evaluating water practices, and identifies rate-making practices are based largely on acceptability to local ratepayers, and that economic efficiency — pricing water to reflect the cost of providing extra usage — is a neglected factor in current rate setting practices.

Proceedings of Conserv 90
The National Conference and Exposition Offering Water Supply Solutions for the 1990s

Compiled by the National Water Well Association

Conceived in the wake of the 1988 drought in the South-Western U.S, Conserv 90 was a five day conference about American water supply concerns. The conference brought together hundreds of water experts from across the states, and through a series of workshops, technical presentations, panel debates, and discussion sessions covered water supply issues: agricultural, municipal, industrial, residential, educational, reuse, drought management, watershed management, planning, water transfer and water resource management.

The *Proceedings* summarizes the various oral presentations, panel discussions and workshops. The summaries are organized by type of presentation (e.g. oral), and further broken down by specific subject topics. It can be an essential resource for Canadian municipal water resource planners, consulting engineers and water supply professionals, agriculture and irrigation practitioners, turf and landscape professionals, environmentalists, lawmakers, and government officials.

Toward A Water Efficient Ontario
Phase I Options

Ministry of Natural Resources

An Ontario Ministry of Natural Resources discussion paper dealing with strategies and options for encouraging efficient water-use and conservation by industries and individuals. The paper presents a well-documented argument on the pressing need for water conservation, citing increased use over the past several decades and projecting into the future the ramifications on water supply if current usage trends hold. The paper also explores water quality issues, and the effects of global warming on current and projected water supplies. The paper concludes with a description of a nine-stage program for reducing water conservation, including: fostering a water conservation ethic at an individual level; water leakage reduction and promotion of water-efficient equipment at a municipal level; the development of water-efficiency programs for the industrial, institutional, and agricultural sectors; and the development of water-efficient codes.

Water
Water-Efficient Technologies for the Urban/Residential Sector

Rocky Mountain Institute

The Rocky Mountain Institute is a non-profit research and education foundation with a self-imposed mandate to foster the efficient and sustainable use of resources. They have written extensively about potable water, and this catalogue represents one of their foremost publications. Most recently updated in 1988, the catalogue lists every type of water-efficient fixture known at the time of publishing. The devices are broken down into the following divisions: faucets, showerheads, toilets, innovative irrigation, pressure reducing valves, and water-efficient plumbing systems. Within each category devices are reviewed according to the following categories: product name; performance characteristics; benefits and effects; applications; construction; installation; independent test results; product references; code listing; cost; shipping data; lead-time for large orders; warranty; and manufacturer, distributor, and supplier of information.

The plumbing-supply business is populated with some large and many small companies with a tradition of low-scale marketing techniques and a focus of providing water as opposed to using it efficiently. This catalogue is one of the few platforms for effectively promoting innovative plumbing equipment, with a focus on water-efficiency.

Note: Many devices listed in this catalogue will not be available in Canada. In addition, Canadian testing procedures and American testing procedures are quite different. Despite how well some of these devices may perform, they most likely will not have received CSA approval. For an account of low-water-volume devices that have received CSA approval refer to the Water Efficient Fixtures Catalogue prepared by the Water Conservation Program for the Regional Municipality of Waterloo (Ontario), listed below.

Water Conservation
American Water Works Association

Researched and Written by William O. Maddaus

An updated version of *Water Conservation Management*, originally published in 1981. This book describes and quantifies the amount of water saved by various water conservation methods — with a particular focus on residential water use — and details approaches to evaluating the benefits and costs of those methods. Of interest to Canadian municipal and utility officials is a clear description of how to select and implement a water conservation plan.

Water Efficient Fixtures Catalogue
Regional Municipality of Waterloo

Compiled and edited by the Water Conservation Office of Waterloo Region

This catalogue is the Canadian equivalent of that published by the Rocky Mountain Institute. Divisions in this catalogue include: water closets; showerheads and hand showers; basin fittings; sink fittings; and industrial/commercial fixtures. Within each division, a general description of each device is given, including water consumption, availability, and whether it has received CSA approval.

Not all available water-efficient fixtures are included. For inclusion in the catalogue, each fixture had to meet regional specifications, as well as industry and government standards. As a consequence, the catalogue lists the best of the "somewhat-water-efficient". Very few of the devices listed are of the "ultra-low-flow" variety.

Water: No Time To Waste
A Consumer's Guide to Water Conservation

Available through Canada Communications Group

A twenty-four page guide to water conservation in a residential setting. Organized on a room by room basis, the guide covers the need for water conservation, the effects of conventional water-using practices, and various options for reducing water-use through changes in habit, and changes to water-using devices. The guide also details how water utilities purify and deliver water, and how they treat household effluent. While exterior water use is covered, the discussion is brief and only skims the surface of this important topic. Aimed at the water consumer, the guide could form a useful part of any public education campaign.

Water Conservation Strategies
An AWWA Management Resource Book

Compiled by the American Water Works Association

Water Conservation Strategies is a compilation of 21 selected articles from issues of the AWWA publication Journal. The issues covered in the articles deal in large part with planning strategies, dealing with drought, and water conservation education for the public. In terms of public education campaigns, several approaches are laid out, and the results of various pilot programs are presented. Though somewhat dated (copyright 1980), much of the information is still relevant, in particular the articles dealing with water conservation and the public.

Water: The Potential for Demand Management in Canada — Discussion Paper

David B. Brooks and Roger Peters, available from the Science Council of Canada

Water: The Potential for Demand Management in Canada, is one of four discussion papers commissioned by the Science Council as part of its study on water resources in Canada, entitled, *Water Policy: Toward the Year 2020*. This discussion paper focuses on how the demand for water can be better managed to ensure its conservation and protection. In particular, the authors examine pricing strategies that reflect waters real worth, how the mandates of water agencies can be expanded to include demand management, and how to encourage more efficient use of water. In this latter regard, water-efficient appliances, fixtures, industrial equipment, and agricultural equipment are all reviewed.

The paper concludes with a preliminary water demand management strategy for Canada, setting priorities and noting barriers for industry, institutions, the agricultural sector, and individuals. In each case, the strategy is to be based on examining the volume of water use, evident conservation opportunities, the practicality of control and monitoring, and water system costs, taking into account conflicting demands for water. Cost-effectiveness was not considered by the authors, because the purpose of the initial set of criteria was to identify sectors for which cost-effective water demand management options appeared to be needed.